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BRUSSELS: WAYS AND WARES

THE DECLARED PURPOSE OF THE BRUSSELS World Fair is to promote international friendship and understanding. At this gay and cosmopolitan city, itself a mixture of races and languages, the nations were to draw together and display their ways of life to each other and demonstrate the fundamental unity of their aims. The Exhibition can hardly be said to have achieved this high ideal, perhaps because at mankind's present stage of development too many obstacles stand in the way—nationalism, group interests and political dogma—which only a universal growth of wisdom will overcome. But the process can be aided by a closer acquaintance with the people of other countries and by an exchange of cultural relations with them, and to this end the Brussels Fair, like other World Fairs, serves a useful purpose.

At Brussels has been created a microcosm of the modern world. The Exhibition shows the participating countries as they really are—industrious, ingenious, immensely energetic and intensely nationalistic, vying with each other to prove their superiority in as many fields as possible. The spirit of rivalry—and not always friendly or healthy rivalry at that—can be clearly seen by all visitors to predominate over the spirit of fraternal understanding. The vices as well as the virtues of our world are on display.

A people's way of life can best be shown by its artistic works rather than by its scientific achievements, and it is to be regretted that the accent in nearly all the pavilions is on material rather than spiritual things. Industrial products occupy the central position, and the arts appear to be merely incidental. The 'wares' not the 'ways' are the keynote of the Fair. One can only conclude that the various national organizers have either misunderstood the purpose of the Exhibition or have found the way-of-life theme too difficult to present. It is easier to dazzle the visitor with a glittering array of scientific wonders than to show him how one's fellow-countrymen live and think, or to convey the ideas that form the basis of government.

How is one to demonstrate Western philosophy to a Japanese? Or Buddhist philosophy to a Mexican? How can one show a Russian what we in England mean by democracy? How can a Russian make a striking display of dialectical materialism? The temptation to gloss over such abstract ideas is strong; it is so much simpler to line up the digital computers and the nuclear reactors, the latest supersonic aircraft and turbo-generators and to say, in effect: 'Look—this is what *our* system produces.' A Martian might be forgiven for concluding that there is not much to choose between the nations on such a material basis.

Yet the national characteristics of the participating countries do shine through the bewildering plethora of mechanical invention. They are apparent in the design of the pavilions, the works of art, the propaganda items and the motivating themes on which the organizers have worked. Admittedly these factors are largely subjective, but it is the subjective things in life that are the most important to us as individuals.

Britain, for example, places the emphasis on tradition. On entering the British Government pavilion, the visitor finds himself in a lofty, darkened cathedral, lit by chandeliers of tiny coloured lights, which resemble stained-glass windows, and pervaded by hymnal, patriotic music. He sees full-size replicas of the Crown jewels and dioramas of Gartered knights. No one can deny that tradition in its various aspects strongly flavours our national life, but the wisdom of concentrating on this as a theme of our display is questionable. There has been no attempt on our part to show the common aims and ideals which we share with other countries, such as republican America and France, nor does it convey to a visitor from behind the Iron Curtain the real nature of the freedom and democracy and equality of opportunity that exist in our country. Better to have concentrated on such themes as British justice, parliamentary representation, freedom of speech and writing, or the education of our children. Fortunately, the rather severe effect of this display is mitigated by other parts of the

British Section—the glimpses of various interesting lines of research, the overwhelming trade exhibition in the industrial pavilion, and perhaps best of all by the two British public houses.

A further interesting comment on national characteristics is provided by a comparison between the Russian and American pavilions, which are conveniently situated side by side. The Russian 'crystal palace' is a glittering and disciplined creation of glass and aluminium, glorified by a flight of steps leading up to the impressive entrance. Its monolithic architecture, designed to inspire awe, suggests the Continental philosophies from which Communism arose. The vast hall contains, besides a comprehensive array of exhibits (including Sputniks), three huge statues—two of idealized workers and one of Lenin. Whatever the merits of the nameless workers, the statue of Lenin makes the liberal Western observer want to protest: 'But no man is as big as all that!' Apparently the condemnation of the cult of personality is not retrospective.

The American pavilion next door forms a profound contrast. Set amid fountains and flowering trees, its airy, honeycombed structure and graceful, circular periphery, open to access on all sides, give a welcome impression of lightness and friendliness. Inside, one finds to one's surprise not brisk American salesmanship but a garden of full-grown trees and an ornamental lake, which breathe an atmosphere of quiet, leisured spaciousness. The Americans are to be praised for being among the very few exhibitors who have made an effort to keep to the spirit of the Fair and who have concentrated on demonstrating their way of life rather than on overawing the visitor with science and engineering—as *they* so easily could have done. The restraint shown by their organizers is quite remarkable. The art of American painters and sculptors is adventurous, full of new subjective concepts and bold experiments, forming a striking contrast with the polished but unvarying realism of the Russian show. The comparison demonstrates, too, the value of art in the understanding of a people. While the engineering marvels of all the industrial countries look very much alike, their works of art show the differences clearly.

Yet it is perhaps these self-same engineering works that express the leitmotive of the Fair that has emerged in practice—the drive of all nations for a higher material standard and a fuller, more leisured life. The very similarity of these multitudinous machines underlines the unanimity of this common aim, which itself provides the best hope that the nations will continue to coexist in peace until the world-wide growth of wisdom makes that peace everlasting.

New Channel Islands Cable

AT the end of June, H.M.T.S. *Ariel* began laying a new Post Office submarine cable to the Channel Islands which will double the circuit capacity to the Islands and also provide a more direct route to London.

Laying commenced at the St. Helier end, and the cable ship will make two trips to lay the full length of cable. Ten submerged repeaters, spaced at about 13 nautical miles, will amplify the signals in both directions. They will be housed in steel cylinders similar to those used in the Newfoundland–Canada section of the Transatlantic cable. The new underwater link, from Tuckton, near Bournemouth, to St. Helier, will be about 130 nautical miles long.

Each of the two existing cables—which will continue to be used—provides 60 circuits; the new one will carry 120 over a completely different route. The present cables, into each of which three repeaters were introduced in 1952, run from a point on the mainland near Dartmouth to Fort Doyle, Guernsey. Two cables then extend the service between Saints Bay, Guernsey, and Plemont, Jersey.

The submarine cable is coaxial, with polythene insulation of 0·62 in. diameter; the inner conductor is 0·16 in.-diameter solid copper. The outer conductor over the polythene insulation consists of six copper tapes applied helically with an over-all copper binding tape. The main cable is armoured with twelve 2 s.w.g. steel armour wires. Shore-ends and land sections have additional layers of polythene insulation and an outer lead sheath, and the shore-ends have an additional layer of armour wires for extra mechanical protection.

The repeaters are energized by direct current fed over the centre conductor from the terminal stations and are contained in cylindrical steel housings. Special terminal equipment is installed in the repeater stations at Tuckton and St. Helier; power units at each end provide closely regulated constant current. In the Tuckton–St. Helier direction, 120 telephone channels are transmitted in the frequency range 60–552 kc/s and, in the reverse direction, 672–1164 kc/s. Pilot frequencies 4 kc/s from the edge of each band are transmitted all the time over the system to provide continuous monitoring and control of performance. Equipment at Tuckton will enable the gain of each repeater to be measured without interfering with traffic.

At Tuckton the 120 telephone circuits will be reduced to ten 12-circuit carrier groups in the frequency range 60–108 kc/s, which will be extended into the inland carrier network. Equipment at St. Helier repeater station will reduce circuits to audio frequencies which will be fed to the Jersey trunk exchange.

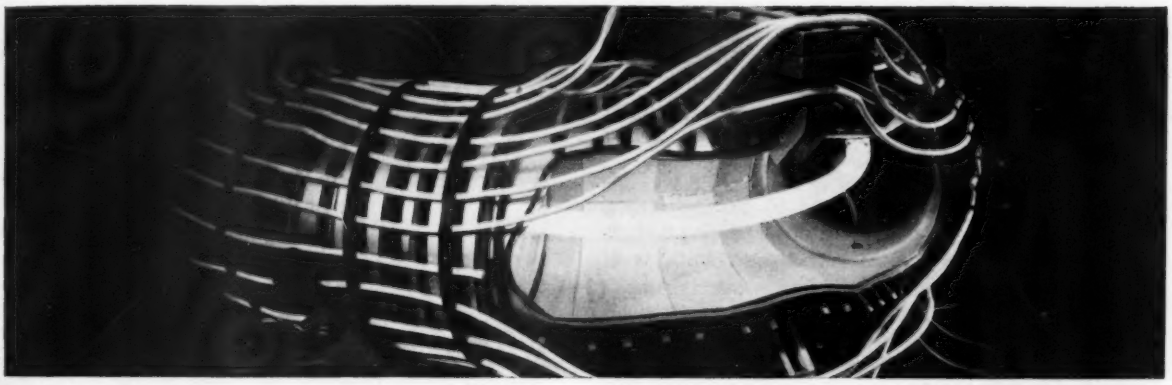
The cost of a 3-minute call between London and Jersey is 3s. 6d., and traffic averages 20 000 calls a week.

Electrical Displays in the British Industries Pavilion of the Brussels Exhibition

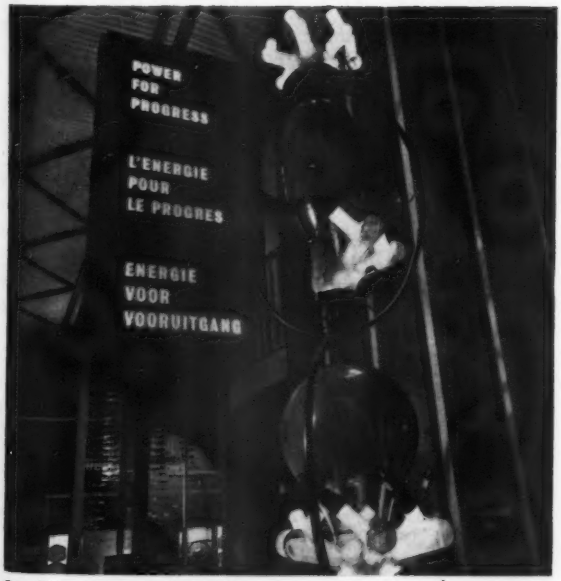
THE Universal and International Exhibition, Brussels 1958, closes on the 19th October. More than 20 million people have so far visited the exhibition, and of these over two million have entered the British Industries Pavilion. Easily one million have seen the British electrical and allied industries display, which is on the largest single stand in the pavilion. Some of the exhibits on the stand are shown in the illustrations on this page.

Among the visitors have been leading personalities from nearly every country in the world, including many from the electrical industries.

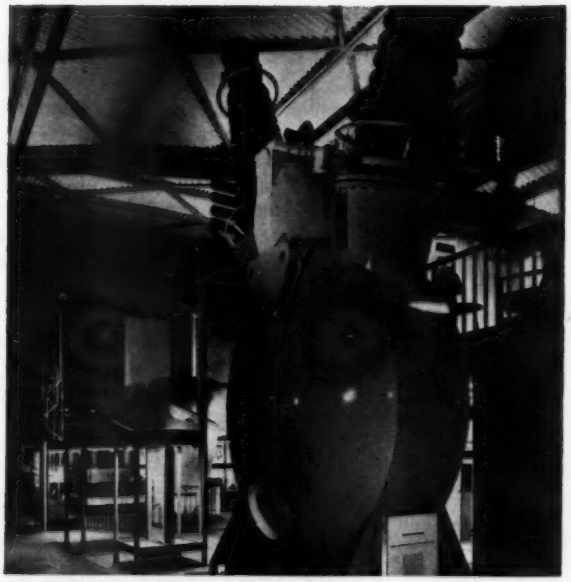
1 *A mural*



2 *Model of Sceptre III*



3 *Mercury-vapour rectifier*



4 *275 kVA oil-filled circuit-breaker*

Technological Humanism

165.742:

On the 29th April 1957 Sir Eric Ashby delivered the 47th Annual May Lecture of the Institute of Metals. Although more than a year has elapsed since then, the widespread interest which the lecture immediately aroused has by no means waned, and frequent references have been made to it—for example, Sir Ewart Smith quoted from it at length in the Fourth Graham Clark Lecture, which was published in the February Journal, p. 68. We feel, therefore, that many members will welcome this opportunity of reading it in full, and we publish it here by the kind permission of the Institute of Metals, in whose Journal it first appeared (1957, vol. 85, part II, p. 461). Sir Eric takes up his appointment as Master of Clare College, Cambridge, this month.

SIR ERIC ASHBY, D.SC., SC.D., LL.D.

I AM a biologist who has turned to administration. My career could be regarded as one long disqualification for delivering a lecture before the Institute of Metals.

Nevertheless I accepted the invitation, because I believe that modern technology is confronting us with an exceedingly perplexing biological problem. It lies in the field of human ecology. It is the problem of how men and communities can adapt themselves to an environment which is changing with unprecedented speed.

Keeping up with Environment

Let me introduce the problem by way of an antithesis between technology and heredity. Napoleon, who died only 136 years ago, was not able to cross the Alps any faster than Hannibal crossed them. Today you can have breakfast in London and lunch in Rome. Gladstone, who died less than two generations ago, was not able to reach more people with his voice than Demosthenes reached with his. Today a prime minister's voice can be heard in the homes of millions. Sixty years ago a ship was out of touch with the world as soon as it lost sight of land. Today a ship can sail into the Arctic and remain as close to the news as a pedestrian in Piccadilly. The rate of change in the last 100 years is of a different order from that in previous centuries; and the changes are not merely advances in technology: they are drastic transformations in the environment of Man.

In contrast to this, Man remains very much as he was when history began. He learns no more efficiently than a pupil in Plato's academy learnt. He thinks no more deeply than Plato thought. His chromosomes are conservative and resistant to change. He responds to new environments not by innovations in his heredity but by the marvellous adaptability of his ancient genetic heritage. This adaptability would be impossible if the only channel of inheritance from one generation to the next were through the sperm and the egg. In Man—and in Man alone—there is a second channel of inheritance. The accumulated knowledge and traditions of society are inherited not through the chromosomes but through education.* Education is the second channel of inheritance. Whether today's children will be able to cope with tomorrow's world depends largely on the inheritance of education which they receive. Over this channel of inheritance we have some influence and we can assume some responsibility; it is a responsibility which none of us would wish to escape, for not only are we the architects of this technological age: we are also the parents and grandparents of the children who have got to live in it.

Technologists and Social Change

This gigantic problem—the adaptation of society to a rapidly changing environment—confronts teachers of all kinds at every level of education. In this lecture I shall focus on one thin layer of the problem, namely one aspect of the higher education of technologists. This is the concern of universities, colleges of technology, and professional institutes such as your own, and it is specially important because technologists are now becoming the pacemakers for social change; communities which formerly developed on the initiative of princes, or bishops, or financiers, or soldiers, now develop on the initiative of technologists. It is no exaggeration to say that the quality of education to be given to technologists may deeply influence the future of the West.

A great deal has been written recently about the desperate necessity to increase the annual output of technologists in Britain.† We are all of us already persuaded that the quantity of technologists must be increased. What we are not at all clear about is the quality of educational inheritance which technologists should receive. This lecture is concerned with quality, not quantity; what I propose to offer you in particular are some reflections on the content of education for higher technology in Britain. One warning before I begin: lectures on education are unlike lectures on metallurgy, for men have been thinking about education for over 2000 years, and some of their thinking never becomes

* Education is here used in the widest sense, to cover the transmission of tradition and culture by instruction, precept, or imitation. The theme is as old as Plato. It has recently been used with good effect by T. Dobzhansky, 'The Biological Basis of Human Freedom' (Clarendon Press, Oxford, 1956)

† See, e.g., 'Scientific and Engineering Manpower in Great Britain' (H.M.S.O., 1956) and 'Engineering and Scientific Manpower in the United States, Western Europe, and Soviet Russia' (U.S. Government Printing Office, Washington, D.C., 1956)

out of date. Anything worth saying has already frequently been said. Anything hitherto unsaid should be regarded with the greatest suspicion.

The Craftsman-Inventor

It is first of all necessary to recollect how technological education arose in this country. The first Industrial Revolution was accomplished without scientists or technologists. Bramah and Maudslay, Arkwright and Crompton, the Darbys of Coalbrookdale and Neilson of Glasgow: these men had no systematic formal education in technology. While wars absorbed the energies and dissipated the capital of Continental Europe, these men and others like them built up British industry until it had no rival in the world. Our industrial strength lay in our amateurs and our self-made men: the 'cultivator of science' (as he was called), the craftsman-inventor, the mill-owner, the ironmaster. It was no accident that the Crystal Palace, that radiant symbol of the supremacy of British technology, was designed by an amateur. In 1851 most people in authority saw no danger in the fact that Britain had no state system of primary education (a third of the population was still unable to read or write); or in the fact that there was scarcely any science teaching in secondary schools ('it is plainly out of the question', said Moberly of Winchester, 'that we should teach chemistry'); or in the fact that there were no opportunities for the study of higher technology except a few in London and in Scotland. It did not seem worth while to spend money on popular education, for industry was flourishing and manpower was cheap; nor did there seem to be any reason why the well-to-do classes (who were concerned with administration and management and not with mere technical details) should depart from their traditional education in the classics. Notwithstanding the Industrial Revolution, science and technology still played practically no part in higher education. Not long before the 1851 Exhibition, the professors of physics and chemistry in Oxford had asked to be excused from lecturing altogether because there were so few students; and although the Cambridge science tripos was established in 1851, there were on the average only about nine successful candidates a year for the first 20 years.*

Between Two Exhibitions

Fortunately there were men of foresight who were unhappy about this situation. The Royal Commission on Oxford University tried to encourage Oxford to pay attention to the physical sciences by saying that unless 'the clergy and gentry . . . are encouraged to keep pace with the progress of Society at large . . . they may find themselves placed below persons in many respects inferior and an opposition may arise between Physical Science and other branches of knowledge'.* The Royal Commission on Cambridge University was even more precise: 'It may be quite true', the Report says, 'that many of the practical . . . details of civil engineering may be best learned in the offices of engineers . . . but the knowledge of mathematics and of mechanical principles, as involved in the estimate of . . . the effects of elasticity, and generally of the operation of forces and pressures is so necessary . . . that no amount of practical skill and experience can ever replace the want of this theoretical knowledge.†

These admonitions, and many others like them, made very little impression on the managers and mill-owners and ironmasters of Britain; these men were prepared to agree that science and technology were appropriate subjects for artisans and the lower middle class, but not for their own sons. And so, when the Society of Arts and the new Government Department of Science and Art did set up schemes to encourage scientific education, these schemes were almost exclusively for the benefit of artisans and the 'labouring poor'. Clearly, admonitions were not enough; a much more powerful impact was needed to overcome public inertia to technological education.

That impact was provided by the International Exhibition held in Paris in 1867. Britain had won awards in nearly every class in the 1851 Exhibition, but in the 1867 Exhibition she had to be content with a bare dozen awards. No longer was there the reassurance of easy industrial supremacy. Instead there was alarming evidence that Britain had made little progress in the peaceful arts of industry since 1851 and that Continental countries had now become very serious competitors.‡ For example, a building was being put up in Glasgow with iron girders from Belgium, and it was asserted by Lyon Playfair that Belgian girders were cheaper because the Belgians had introduced economies depending on chemical analysis of the ore and limestone and fuel. British fabrics were being sent to France to be dyed on the ground that the French had techniques superior to our own. The French explained this by saying, 'the foreigner thinks it is our water and our sunshine, but we say it is our chemistry'.§

Technological Institutes Abroad

What had happened in the interval between the two exhibitions to bring about this change? There were many causes at work, but the chief cause undoubtedly arose from Britain's monopoly of much of the 'know-how' she had acquired during the Industrial Revolution. Up to 1825 it was a penal offence to enlist English artisans for employment abroad. Well on into Queen Victoria's reign, the export of spinning machinery to foreign countries was prohibited. When Continental countries began to build railways and mills and factories,

* Some interesting information on this and related topics has recently been assembled by D. S. L. Cardwell, 'The Organization of Science in England' (Heinemann, London, 1957)

* 'Report of the Royal Commission on the University of Oxford', 1852
† 'Report of the Royal Commission on the University of Cambridge', 1852
‡ Letter from Dr. Lyon Playfair to the Rt. Hon. Lord Taunton, *Journal of the Society of Arts*, 1867, 15, p. 477
§ 'Report of the Select Committee on Scientific Instruction', 1868

they found it extremely difficult to obtain access to British techniques and practices. They had to make up for half a century of lost time. Their response was to produce a new species of professional man: the manager-technologist. To this end they established polytechnics with the specific purpose of training not the rank and file of workers, but engineers, designers, chemists, and potential managers for industry. In Zürich, in Dresden, in Delft, even in the United States, there arose in mid-century technological institutes which had no parallel in Britain. Their function is well summarized by the words used to describe the Massachusetts Institute of Technology (founded in 1864) as a place 'intended for those who seek administrative positions in business . . . where a systematic study of political and social relations and familiarity with scientific methods and processes are alike essential'. In addition, almost every manufacturing town on the Continent had its continuation school where workers were obliged to extend their education up to the age of 16 by part-time day-release. And beside these there were specialist technical schools such as the Metallurgical School in Bochum (in Rhine-Westphalia), where potential managers and supervisors in the local factories and mines were released from industry for three years' full-time study.*

The prime purpose of this widespread system of technological education abroad was not humanitarian: it was to enable Continental countries to catch up to and overtake British industry. Accordingly, in the polytechnics emphasis was laid on a combination of science, technology, and general knowledge, suitable for men who would direct technical policy. Already by 1867 this experiment had begun to yield results. The results were obvious to Britain, and it was this challenge from the Continent, rather than a demand from industry at home, which drove Britain finally to set her educational house in order.

Compulsory Education

The leeway to be made up was truly appalling. Continental countries like Prussia had enjoyed compulsory primary education and compulsory further education with day-release for over a generation; and for years the *Realschulen* of Germany had made science an integral part of secondary education. England in 1867 had no State school system, primary or secondary, and no general compulsory education. Continental universities were generously financed by the State, and many of them had well established laboratories in close touch with industry. Bunsen in Heidelberg, Kekulé in Bonn, Liebig in Munich, Wöhler in Göttingen: all these chemists were training men who were accepted for industrial posts. England in 1867 was contributing scarcely any money by way of public funds to her universities, and her universities were contributing scarcely any technologists to industry. Per head of population, England had only about a quarter of the number of students Germany had. There was no Clarendon Laboratory in Oxford nor Cavendish Laboratory in Cambridge. Owens College in Manchester, 16 years after its foundation, had only 113 students. Efforts of the Prince Consort to establish an industrial university in London had failed.

Because of this leeway, England could not meet the challenge from the Continent by building polytechnics; for she had no adequate foundation of schooling on which to build. And so, even after the need for technical and technological education had been realized, the response was slow and uncertain. In 1870 the Government introduced compulsory primary education. But Parliament was still unwilling to support trade schools and technical schools; it was the Livery Companies which first undertook to assume this responsibility. In 1867 they set up the City and Guilds of London Institute, which fathered not only the first genuine technical college (at Finsbury) but also (at South Kensington) the first genuine institute for higher technology. Not until 1889 did public authorities take over elementary technical education, and even then education in higher technology was not made a public responsibility; most of it was left to the universities and university colleges.

The Fight for Respectability

Here—in my opinion—is one clue to an understanding of our present curricula in higher technology. The spur to technological education in universities was not in the first instance a demand from industry for scientifically trained managers; it was the determination of a few far-sighted men to create a supply in anticipation of a demand. Accordingly, the pioneers of technological education in universities found themselves having to justify their subject on academic and not utilitarian grounds. They could not prove to their academic colleagues that higher technology was useful, and so they had to make it appear respectable. Accordingly they felt obliged to follow the fashions set by more venerable faculties. (Even as late as 1861 the University of Glasgow, which claims to have the oldest university chair of engineering in the kingdom, did not consider engineering to be 'a proper department in which a degree could be conferred'; and it remained for years in the Faculty of Arts.) Therefore when, under the influence of German scholarship, specialization became fashionable, technology followed the fashion. Part of the price paid for following the fashion was a narrowing of the curriculum in every discipline—not only in technology. No longer was it necessary for a man taking the classical tripos at Cambridge to pass first a tripos in mathematics and mechanics. No longer did the London B.A. require some knowledge of both the humanities and the sciences. The universities assumed (and with some justification in those days) that secondary schools would provide a balanced general education and that universities could concentrate on turning their best men into experts: experts in classical philology, or history, or chemistry.

Where the arts and sciences led, technology followed,

* A description of this metallurgical school is given in the 'Second Report of the Royal Commission on Technical Instruction', 1884, p. 117

and the trend in higher technological education was consistent with the pattern of British industry. In Continental countries, many technological experts found themselves in the board-room or acting as administrative civil servants. Their education prepared them for these responsibilities. In Britain administration and policy-making remained largely in the hands of men with no technological training. The chemist from Roscoe's laboratory in Manchester or from Graham's laboratory in London might look forward to a career in industry as a chemist. But there was no great demand from industry to equip him to manage, or to be responsible for, human beings. Higher technological education abroad was from the beginning intended to produce not only experts but also managers and leaders in industry. In the British economy of the 1860's and 1870's, there was no shortage of men for the board-room: the shortage was in the design office, the laboratory, and the plant; therefore the pattern of higher technological education set in this country at that time was one to produce experts to advise on policy, not leaders to make policy. With modifications, accretions, and improvements, that pattern has persisted ever since.

The False Assumptions

This long historical digression enables us to diagnose the present state of higher technological education in Britain. On the one hand, there are grounds for satisfaction: there is no reason to believe that any foreign university can teach the practice and techniques of science and technology better than they are taught in such places as Imperial College or Manchester or Cambridge. Regarded as a preparation for doing nothing but organic chemistry, or non-ferrous metallurgy, or light electrical engineering—in other words, regarded as a production line for highly differentiated experts—there is nothing much wrong with technological education in Britain. On the other hand, grounds for anxiety do exist, for buried at the foundations of our system for educating higher technologists there are two assumptions, both of which are wrong. The first assumption is that the technologist has had a balanced schooling with a thorough grounding in what are vaguely called 'the humanities'. This assumption may have been justified 50 years ago.* Today it is no longer justified. The would-be technologist has had to decide in his early 'teens to go up the school on the science side and not on the classical side, and he has to specialize for ever afterwards. No secondary education is so overspecialized as ours in Britain.

The second assumption is that the technologist is to become and to remain an expert to serve the manager, never to become a manager himself. This assumption, also, is no longer justified; and in the second Industrial Revolution, which is upon us now, it will become an utterly obsolete assumption. Because these two assumptions are still made, the question of including the humanities in higher technological education is still not taken seriously. True, it is a subject worn threadbare in graduation addresses, educational conferences, and academic pamphleteering; but (with one or two exceptions) it has not yet become a subject for faculty decisions or senate resolutions. Ask professors of technology what they are doing about it, and they reply that the curriculum is already overloaded and nothing more can be added. Ask the advice of arts professors, and some of them will reply that a faculty of arts is not a faculty of culture: it has no contribution to offer towards civilizing the 'savage technologist'. The historian (they say), pursuing his minute enquiries into mediaeval charters, has no more relevant contribution to make to technological education than the biologist has, assiduously analysing the urine of mice. There are, you see, resistances from both sides: faculties of technology cannot find room for the humanities; faculties of arts—in this context at any rate and if we are to believe some arts professors—do not regard themselves as trustees responsible for communicating the values and traditions of Western civilization to other faculties.

Training in Other Countries

Contrast this with the training being given to technologists in other countries. I quoted just now the purpose of the Massachusetts Institute of Technology: to train men for posts where 'a systematic study of political and social relations and familiarity with scientific methods and processes are alike essential'. The student at the Massachusetts Institute of Technology must devote a considerable portion of his time throughout all four years of his course to English composition and literature, history, psychology, international relations, and economics; and these subjects are taught in a way which is relevant to technologists. In the Swiss Federal School of Technology at Zürich, third- and fourth-year students include in their course law, economics, and management; and there is a department of general education with 12 professorships covering foreign languages, philosophy, history, law, and political economy. All students must register for at least one course in this department. In the Technical University of Delft, there is a so-called *Studium Generale*, which provides lectures on religion, philosophy, music, and art; something similar was already being done there over 70 years ago, in the 1880's. Even technological institutions in the Soviet Union devote some time to the humanities and the social sciences.* The British Commonwealth has not ignored these examples: in the New South Wales University of Technology, there is a Department of Humanities, with a full professor at its head. Even some English technical colleges have introduced an

* And not only in the humanities: it is now forgotten that the 'Sixth Report of the Royal Commission on Scientific Instruction' (1872–75) recommended unanimously that in all public and endowed schools six hours a week should be devoted to science and that science should constitute one-sixth of the leaving examination. Such a recommendation would to-day be regarded as unreasonable by most secondary schools. It is important to recollect that the curriculum in most secondary schools is much less balanced now than it was nearly three generations ago

* See N. de Witt, 'Soviet Professional Manpower' (National Science Foundation, Washington, D.C., 1955)

element of the humanities into their courses.* Nevertheless, universities in Britain are not yet persuaded that the humanities are an essential ingredient in higher technological education. Many universities do indeed arrange opportunities for students to broaden their interests through voluntary attendance at lectures on art and music and the like. This is admirable, but it is a very different thing from recognizing certain humanistic studies as an integral part of a technologist's formal higher education.

Selecting the Humanities

At this stage I must ask you to accompany me into another digression. It is a thankless task to define the humanities, but when I talk about including the humanities in higher technological education, there must be no doubt about which humanities I mean. I do not mean courses on the appreciation of poetry or music or pictures. In my experience the student who whistles Bartok or reads Dylan Thomas or buys a Picasso reproduction for his room has come to care for these artists without any help from formal university courses. That sort of appreciation we can safely leave to the students themselves (although we should certainly encourage it in every way we can); it is just as likely to appear among students of technology as among arts students. (In fact, there is something to be said for not being an arts student if you care for literature, because you then avoid the earnest but misguided species of arts don who believes that a student cannot read *Anna Karenina* or *King Lear* or *The Turn of the Screw* unless some university teacher has first interposed himself between the student and Tolstoy or Shakespeare or Henry James, to deaden the impact of genius by explaining what these writers really intended to say to their readers.) We can safely disregard the sentimentalists who say that faculties of technology fill the minds and starve the souls of the young. There is no evidence that the souls of technologists are starved. There is evidence—as I hope to persuade you—that the minds of most technologists are deficient in certain arts subjects needed for their professions.

So let us be quite hard-headed about the humanities which should be included in higher technological education. There are four criteria for selecting them. First they should not include subjects which can and ought to be taught at school. Second, they should be taught as genuine humanities: that is to say, they should deal with the creative and social acts of Man and particularly with value-judgments about these acts: Man's ideas of right and wrong, of good and evil, of justice, freedom, and government. Third, they should be taught in such a way as to be relevant to the contemporary world and to technology. (This does not mean we have to invent new-fangled humanities: nothing could be more relevant to the contemporary world than parts of Aristotle's *Politics*.) Fourth, humanities at this level of teaching should be instruments to enhance the individuality of students, to resist that levelling of differences in taste and personality, that tendency to increase social entropy, which is a melancholy consequence of the modern techniques of mass communication.

Technologist and Gentleman

Indeed, what is needed is nothing less than a revision of the idea of a liberal education. The *Oxford Dictionary* defines liberal education as 'education fit for a gentleman'. That is still an acceptable definition; it is the idea of a gentleman which has changed. A century ago, when Britain awoke to the need for technological education, a gentleman belonged to what was called the leisured class. The occupations of his leisure did not require any knowledge of science or technology. Modern gentlemen do not belong to the leisured class. Many of them work something like a 70-hour week, and more and more of them are finding that their business requires expert knowledge. Even members of the House of Lords find themselves called on to make decisions about radioactive fall-out, about overheating during supersonic flight or the strontium content of bones. Ministers and senior civil servants have to deal with highly technical policy in the D.S.I.R. and the Ministry of Supply. Even such a gentlemanly subject as the state of the River Thames cannot be understood without some knowledge of oxidation and reduction, detergents, and the biochemistry of sewage. Dare I suggest that, in order to be a gentleman nowadays, one has to be something of a technologist?

But technology alone will not make a modern gentleman. And this brings me to the core of my lecture. It is nothing new to suggest that technologists should know something of the humanities. I want to go farther: I want to suggest that, for the gentleman-technologist, certain of the humanities are an integral part of technology. 'Technological humanism' is not just a rhetorical phrase; it has genuine content.

Social Content of Technology

For technology is inseparable from men and communities. In this respect, technology differs from pure science. It is the essence of the scientific method that the human element must be eliminated. Contrary to the assumptions of some people, science does not dispense with values; but it does eliminate the variability of human response to values. It concerns itself only with phenomena on which all qualified observers agree. It describes, measures, and classifies in such a way that variation due to human judgment is eliminated.

Unlike science, technology concerns the applications of science to the needs of man and society. Therefore, technology is inseparable from humanism. The technologist is up to his neck in human problems whether he likes it or not. Take a simple example: the civil engineer who builds a road into a new territory in tropical Africa. He may assert that it is not his business to take into account the effect his road will have on primitive

* 'Liberal Education in a Technical Age' (London, 1955)

villages up-country; but his road is in fact a major experiment in social anthropology. He does not need to be a professional anthropologist, but he cannot afford to be utterly ignorant of the implications of his work. He is a technologist, not a pure scientist: the social consequences of his work are therefore an integral part of his profession. Take another example from one of the most ancient technologies: medicine. Chemotherapy and preventive medicine and contraceptives between them have enormously altered the pattern of family life. The next generation will inherit from us a surplus of elderly people. This situation sets problems which have given rise already to a new subject called gerontology. Now the problems of gerontology are not merely scientific: they involve some of the perennial issues of humanity—family affection, group loyalty, and social justice. The practitioner in social medicine is a technologist: he cannot repudiate these involvements.

The Path to a Liberal Education

Long ago, in *Science and the Modern World*, A. N. Whitehead saw the essential unity between technology and humanism. He said:

> A factory with its machinery, its community of operatives, its social services to the general population, its dependence upon organizing and designing genius, its potentialities as a source of wealth to the holders of its stock is an organism exhibiting a variety of vivid values. What we want to train is the habit of apprehending such an organism in its completeness.

'... the habit of apprehending a technology in its completeness'—this is the essence of technological humanism, and this surely is what we should expect an education in higher technology to achieve. How is it to be achieved? Ninety years ago, when Thomas Henry Huxley was giving evidence before a Select Committee on Scientific Instruction, he poured scorn on the universities because they made literature and grammar the basis of education and (as he put it) 'they actually plume themselves upon their liberality when they stick a few bits of science on the outside of the fabric'. It will not do for us, 90 years later, to reverse the process and to plume ourselves on our liberality when we stick a few bits of the humanities on the outside of the fabric of higher technology. That would not achieve our purpose; it would only generate in students a contempt for the humanities, analogous to the contempt which public schoolboys in the 1860's had for science. It is no good trifling with this problem. We must cut the path to a liberal education *through* a man's specialism, not by by-passing it for an hour or two a week.

The Mischievous Antithesis

It should be our business in higher technological education to persuade students that they cannot practise technology without continually reflecting upon its social implications, and that some understanding of the humanities is essential to this reflection. For a metallurgist to take a course in general history in order to acquire a little culture is an innocent but not necessarily a very profitable amusement. But if the metallurgist studies the social and economic history of the Industrial Revolution; if he learns how the making of iron followed the forests across Europe until coal replaced charcoal; if he realizes how mining and the building of railways and canals stimulated the study of geology, and how this in turn brought men face to face with the evidence for organic evolution; if he considers the effect which the introduction of electric power has had on the distribution and layout of factories, and the effect which aluminium alloys have already had (through world transport) on the conduct of diplomacy: then history becomes integrated with metallurgy; his humanism becomes a relevant part of his day-to-day thinking. May I be allowed to quote to you a paragraph I have already published on this matter:*

> Suppose a student decides to take up the study of brewing: his way to acquire general culture is not by diluting his brewing courses with popular lectures on architecture, social history, and ethics, but by making brewing the core of his studies. The *sine qua non* for a man who desires to be cultured is a deep and enduring enthusiasm to do one thing excellently. So there must first of all be an assurance that the student genuinely wants to make beer. From this it is a natural step to the study of biology, microbiology, and chemistry: all subjects which can be studied not as techniques to be practised but as ideas to be understood. As his studies gain momentum, the student will naturally become interested in the economics of marketing beer, in public houses, in their design, in architecture; or in the history of beer drinking from the time of the early Egyptian inscriptions, and so in social history; or in the unhappy moral effects of drinking too much beer, and so in religion and ethics. . . . It appears to-day as though technology will become the key to general culture. Technology: not science; because scientific systems are too self-contained—they exclude too many factors, including Man—whereas the technologist has to make something which requires as its ingredients not only science but an understanding of popular art and commerce, of psychology, something of morals and justice, and skill in the art of communication. A technologist who cannot weave his technology into the fabric of society is not first rate; a technologist who can weave his technology into the fabric of society can undoubtedly claim to have . . . general culture.

If these arguments are acceptable, the mischievous antithesis between specialization and general culture disappears.

Ways and Means

I must not shrink from the last step. Anyone can blow bubbles about education for an hour. But educational bubbles have no value unless they can be stabilized; and the only stabilizers are curricula and time-tables. 'Very well,' you will be saying, 'what does all this involve in (for example) the weekly time-table of a civil engineer in a British university?'

I shall try to tell you. It involves a little more time in the undergraduate course, secured either by cutting some subjects down or by lengthening the course. Since Britain is about the last country in the world to attempt to train technologists in three years from the post-intermediate stage, I would not regard this as a very grave obstacle. It involves a little more money. Since it costs £45 000 to train a bomber pilot† and about £1500 to train a technologist, I would not regard some

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* *Research*, 1955, **8**, p. 419
† *The Times*, 13th February 1957

additional cost as a grave obstacle either. It involves some newly designed courses which are within the capacity of lecturers normally to be found in faculties of arts, law, and economics.

Here are some examples of the choice of courses these lecturers might offer to technology students:

1. A course on ethics and jurisprudence, with some discussion of the principles of law and justice (such as might be given by a legal philosopher)
2. A course on the industrial and social history of Europe since the 17th century, with emphasis on the social effects of technological change (such as is already offered at the Dutch Institute of Social Studies at The Hague)
3. A course on political theory, political institutions, and the history of guilds and trade unions (this would be an opportunity for medieval as well as modern historians)
4. A course on industrial psychology
5. A course on sociology and social anthropology
6. A course on the history of technology, including readings from the classics of science and technology (this might go some way towards meeting one criticism of all present courses on technology, namely that it is possible to get a first-class honours degree without ever having read a work of genius)
7. A course on linguistics and communication (a development of some of the material contributed to the Communication Research Centre at University College, London).*

Not every student should take every course. It would be very much better that a student should pursue one rigorous course over a period of, say, two years (with the discipline of reading and essay writing and examination which should be required in such a course) than that he should ramble in a dilettante fashion among several courses. The courses would have to be prepared specifically for technologists, and it is important that they should be used as an opportunity for exercises in communication between students; for inarticulateness is an occupational disease among technologists; and it is a disease which I believe could be very much relieved by this simple prophylactic treatment.

Templates in the Mind

Among the criticisms which are iikely to be levelled against such courses as these, there is one criticism I wish to anticipate. Courses like these (it will be said) are not detailed enough to give the technologist mastery in any of these fields, but they may give him the illusion of mastery. It is not a serious criticism, for the same might be said of most university courses, particularly in the humanities: a student who has passed an examination in English usage has no right to consider himself a master of English prose. Nor, I think, is it a valid criticism, for it will have to be made clear that the purpose of the courses is not to train practitioners but to provide ideas which will act as templates in the mind. On these templates the technologist can shape his own thinking from his own experience; without them he will be unable to comprehend his technology in its completeness.

'Liberality in education', Samuel Alexander once wrote, 'is a spirit of pursuit, not a choice of subject.' If technologists are to enter fully into their responsibilities in the world of tomorrow, they have to adapt themselves not only to novel technologies: they must also be able to adapt themselves to the social consequences of the novel technologies. Their prospects of adaptation certainly depend in part on the spirit with which they pursue technology as undergraduates. To pursue technology in a spirit of liberality, they need not only a thorough training in the theory and practice of technology (they get that already); they need also an understanding of men and communities such as is acquired through literature and history and the social sciences.

The Classical Present

Let me end by summing up in one minute what I have been trying to say for an hour. All industrial peoples have to solve a great problem in human ecology, namely how to adapt themselves, through the second channel of inheritance, to the social climate which is being created by modern technology. Technologists have a special responsibility to solve this problem for themselves and to reflect on its implications for their fellow citizens. I believe that the solution for technologists lies through the inheritance of education they receive; and I am persuaded that the appropriate education for higher technology is one which does for contemporary civilization what our traditional classical education has so successfully done for the civilizations of Greece and Rome.

* 'Studies in Communication' (Secker and Warburg, London, 1955)

NAVAL AIR-DEFENCE RADAR

H.M.S. *Victorious*, the reconstructed aircraft-carrier, now has on board a new type of radar and display system giving long-range warning of approaching enemy aircraft and also providing range, bearing and height data for the control of interceptions by fighter aircraft.

One pencil beam is used for the long-range warning and is fixed in elevation as the antenna rotates. Other pencil beams rotate and also scan separate, but contiguous, vertical sectors in synchronism, thus providing data for computing the range, bearing and height. The r.f. power is produced by very-high-power magnetrons. A microwave lens, of diameter and focal length both about 14ft, is used to focus all the beams. It is constructed by spot-welding an arrangement of aluminium waveguides of different rectangular cross-sections and lengths. Each beam has a separate receiver channel, with special automatic frequency control to correct for frequency variations in the magnetron caused by changing path length.

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330kV TRANSMISSION SYSTEM FOR RHODESIA

The Kariba Gorge hydro-electric scheme will provide outputs of 1200 MW and 8000 kMWh per annum for the Federation of Rhodesia and Nyasaland. Mr. Lyon describes briefly how a 330 kV system was selected and designed for transmitting the power to consuming centres up to 300 miles away. The article is based on a paper (No. 2583) entitled 'The Design of the 330 kV Transmission System for Rhodesia', by Mr. F. C. Winfield, M.Eng., Member, Mr. T. W. Wilcox, Member, and the author, all of whom are with Merz and McLellan. The paper was published individually in March and read before the Supply Section on the 30th April 1958; it will be republished in Part A of the Proceedings.

G. LYON, M.SC.(ENG.), MEMBER

THE Federation of Rhodesia and Nyasaland comprises an area nearly six times that of the United Kingdom and extending about 1000 miles from north to south. Its white population is only a quarter of a million, equivalent to that of Newcastle or Coventry. The native population of about seven million is distributed almost equally among the three territories, whereas the largest part of the white population is concentrated in Southern Rhodesia, with some 65000 in Northern Rhodesia and only 7000 in Nyasaland.

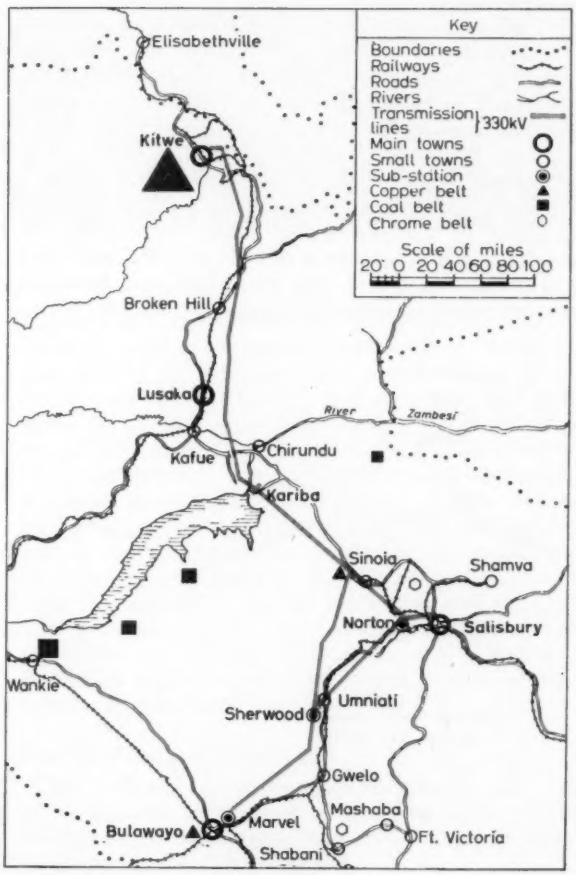
At present almost all the electric power is supplied by coal-fired stations, most of the coal being obtained from the famous Wankie Colliery, near Livingstone. Major thermal stations exist at Salisbury, Bulawayo, Umniati and at four mines in the copper belt near Kitwe. The coal is transported by a single-track railway, which becomes more seriously choked with mineral traffic each year, particularly the track running north to the copper belt. Shortage of coal here has led to supplementary wood burning in the power stations, and a 220 kV transmission line has been built to bring a supply of hydro-electric power from the Belgian Congo.

Kariba Dam

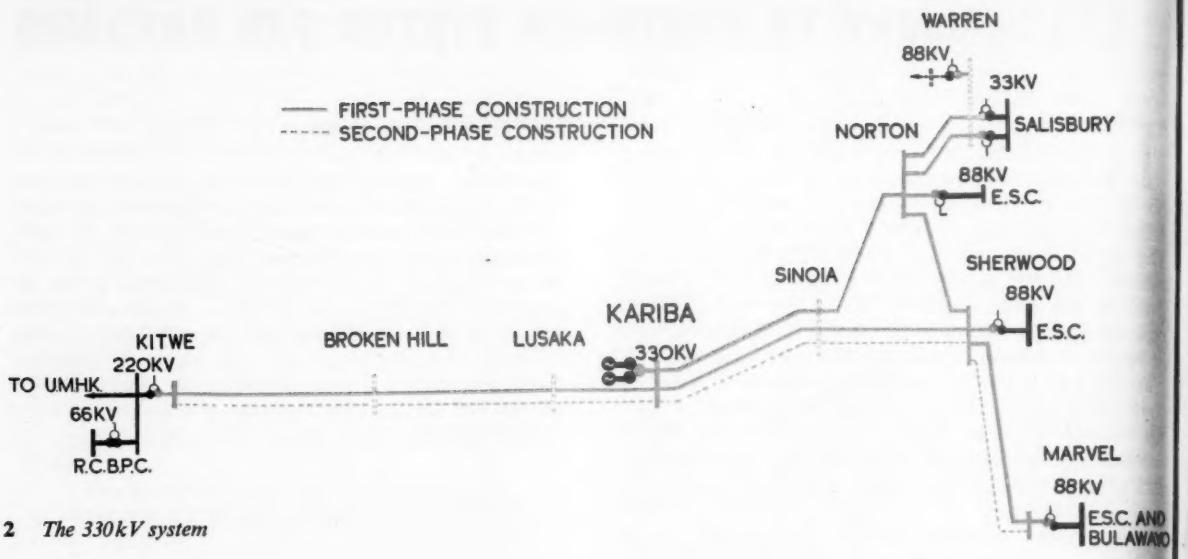
The growth of total load in Rhodesia has now reached the point where the development of the hydro-electric resources of the Zambesi River is justified. Accordingly the Federal Government, through the agency of the Federal Power Board, has put in hand plans that have been maturing for a good many years to dam the Zambesi at Kariba. The project is designed for a power output of 1200 MW or more when complete, and the reservoir produced will extend 160 miles up river to form the latest in the list of 'largest man-made lakes'. Work on the dam was interrupted early this year by the record floods, which were well reported in the Press; but it is satisfactory to know that it is expected to catch up to the schedule on civil-engineering work by the end of 1958, while the electrical and mechanical construction work suffered practically no set-back.

Kariba is some 270 miles from Kitwe, the receiving centre in the copper belt, and about 250 miles on the average from the consuming areas in the south, as can be seen from Fig. 1. To transmit the power to these load centres requires a large high-voltage transmission system.

The design and execution of a major transmission system entails consideration of a wide range of problems. In addition to the design of the system itself and the specification of the characteristics of the plant, there may be unusual geographical, transport or climatic conditions to be considered, particularly in such a relatively undeveloped country as the Federation of Rhodesia and Nyasaland. The 330 kV system in many ways resembles the textbook example of a high-voltage transmission system associated with major hydro-electric



1 *Location of transmission scheme*



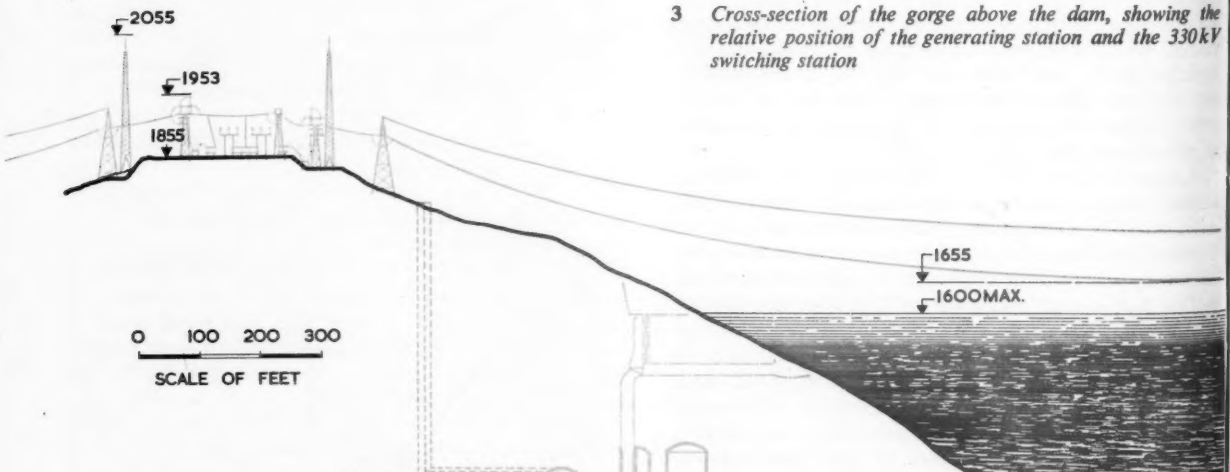
2 *The 330 kV system*

development. While the relatively undeveloped nature of the country presented problems such as those of transport and communication, it also permitted the consideration of the transmission design without the incubus of past development to prejudice the choice of system characteristics.

Choice of Voltage

Several standard a.c. transmission voltages could be employed for the powers and distances concerned, and many schemes at voltages of 220 kV, 275 kV, 330 kV and 380 kV were compared. The comparison was based on schemes which would give similar performance at various stages of development, judged from the point of view of voltage regulation, normal transmission capacity and transient stability. On systems of this general character the maintenance of synchronous stability between the generators and other synchronous machines when disturbances occur is a major problem, and may restrict the amount of power that can be transmitted to lower values than those set by considerations of voltage control.

It is generally accepted that the curves relating cost to power and distance of transmission at various voltages have very flat minima, which allows a good deal of latitude in system design. One positive comparison of alternative systems is the capital cost incurred, and this



3 *Cross-section of the gorge above the dam, showing the relative position of the generating station and the 330 kV switching station*

4 *Aerial view of Kariba Gorge*

was estimated in detail for the 220 kV, 275 kV and 330 kV schemes. 380 kV was found to be too high a voltage: the transmission capacity of one circuit at this voltage is high enough to make single circuits technically adequate on several routes for many years. This leads to an inflexible system unless relatively high expenditure is incurred in the early stages merely to provide stand-by facilities. The period of relative inflexibility is less for the 330 kV schemes, and the initial-cost disadvantage soon disappears. The 330 kV system planned as a result of these studies is shown in Fig. 2. With some future tapping and switching stations such as those indicated, this system is expected to be sufficient to supply the local networks, operating mainly at 88 kV, up to the full development of 1200 MW at Kariba.

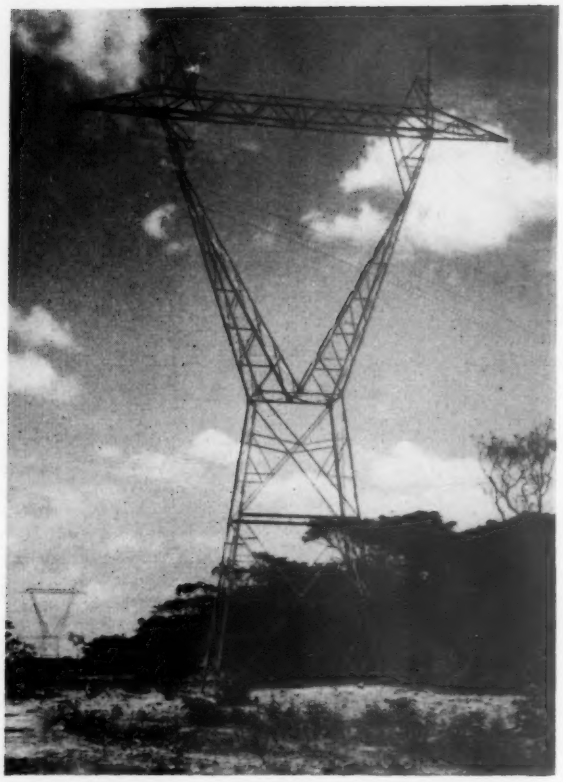
Transport Problems

The determination of the ratings of the major items of plant, such as generators and transformers, was considerably influenced by transport restrictions—including the effect on transport of the seasonal heavy rains, which render many of the unmetalled roads impassable for about four months. The railways are mainly single tracks of 3 ft 6 in. gauge and limited axle loading, and they are served by two ports in Portuguese East Africa. At Lourenço Marques there are 80-ton cranes, but the rail haulage is longer than that from Beira, which has only 20-ton cranes. Hence extensive use must be made of ships' cranes for the lifts of about 100 tons required for the transformers and major generator parts. Two special 102-ton railway wagons are being provided, as well as a 100-ton road vehicle, and the movements of these trucks have to be carefully synchronized with those of the ships carrying the heavy loads. All material for Kariba will be delivered at Lions' Den railhead, about 150 miles away, and a special road 105 miles long is being constructed to give access to Kariba on either side of the river from the main road between Salisbury and Lusaka.

Stations, Plant and Equipment

The Kariba 'A' power station is cut into the solid rock of the right, or south, bank of the river, and the main 330 kV outdoor switching station is on a rather awkward site some 600 ft above (see Fig. 3).

The 100 MW generators are connected in pairs to the



5 *Single-circuit tower nearing completion*

18/330 kV step-up transformers, which consist of single-phase 80 MVA units, connected by oil-filled cables in a vertical shaft to the 330 kV double-busbar switchgear in the outdoor substation. Each generator is controlled by an 18 kV air-blast circuit-breaker. The 'A' station contains 600 MW plant, and the planned capacity of the project—1200 MW or more—will be reached when the 'B' station is built in the left, or north, bank of the gorge at a later date. In the 'A' station the generators and their switchgear are accommodated in the main machine hall, while the transformer and remaining auxiliary equipment are in an adjacent hall connected to the main hall by transverse galleries.

The site of the 330 kV switching station presented many difficulties on account of the irregular nature of the country above the gorge, shown in Fig. 4. The best site available was that obtained by flattening the tops of two small hills almost directly over the generating station, but the civil-engineering cost of this operation made it important to adopt a compact layout for the switching station. Various means of saving space were adopted, such as using an elevated level for the busbars, enabling the selector isolators to be mounted beneath; bulk-oil circuit-breakers with integral current transformers; using vertical-break isolators; and mounting the by-pass and one circuit isolator on the same gantry, one upright and one inverted. Space for substation sites at receiving points was not difficult to obtain, but the arrangement devised for Kariba was standardized throughout the system.

Protection

Rhodesia is one of the worst lightning areas of the world and much thought was required in the design of the lightning-protective measures. Single-circuit lines of flat configuration with double overhead earth wires were adopted to eliminate the risk of simultaneous lightning faults which might occur on lines of double-circuit construction. It is interesting to note that a broadly based specification for the line showed the conventional waisted type of lattice tower, shown in Fig. 5, with a standard span of 1500 ft, to be the most economic, in spite of the apparent attractions of the portal type of tower. Glass insulators and twin steel-cored aluminium conductors of 0·35 in.^{2} copper equivalent section are being used.

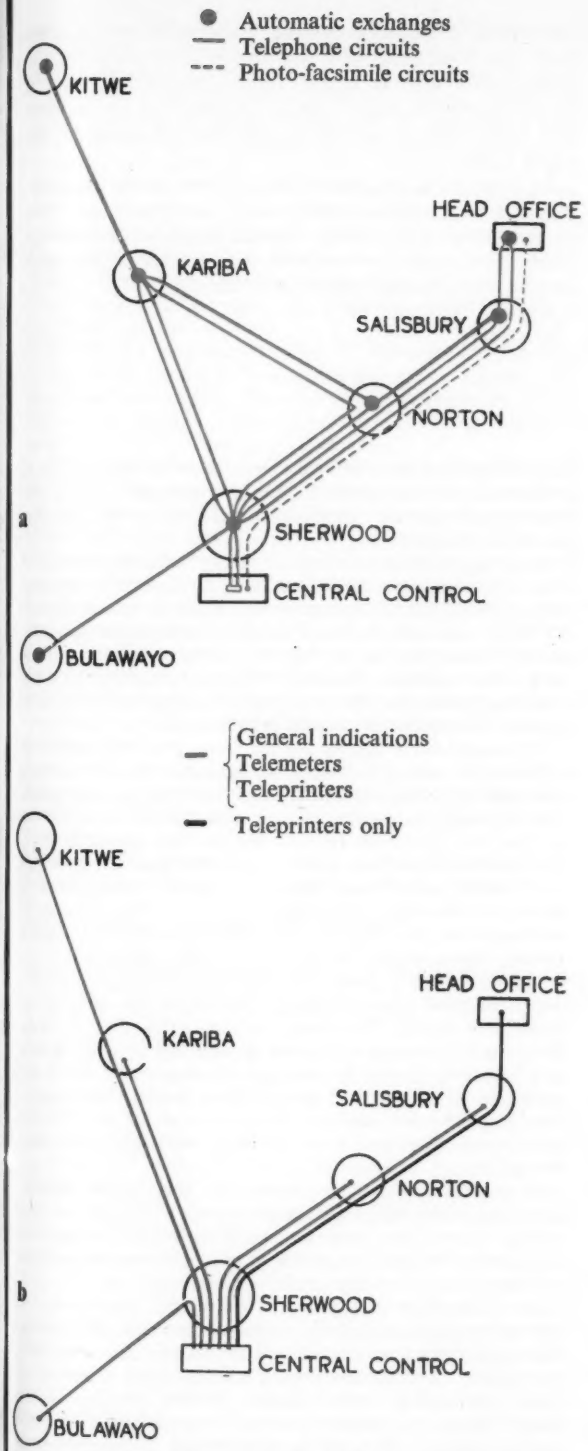
Coupled with high lightning incidence in Rhodesia is a prevalence of high earth resistivity, and, to obtain the low tower-footing resistance necessary to render the shielding effective, buried galvanized-iron counterpoise wires are being used along those sections of the lines which lie in areas of high resistivity.

The terminating transformers are being provided with 330 kV lightning arresters, giving a margin of protection between the 1350 kV insulation level of the transformers and the spark-over and discharge voltage levels of the arresters. As an additional measure of protection, especially for the other substation apparatus, along the terminal mile of all lines the normal impulse level of about 1400 kV is reduced by means of arcing horns to 1250 kV.

Siting of Routes

The selection and survey of line routes were not easy. In Southern Rhodesia, the Government survey authorities assisted by giving priority to aerial-survey maps for use in routing the lines. In the north, however, no Government aerial survey was in progress, and suitable maps were scarce.

Special aerial survey was considered but eventually abandoned in favour of normal ground profiling. Prime routes were selected by aerial examination and ground checking, assisted by stellar fixes provided by the meteorological authorities. On these routes narrow survey traces were established, after which the wayleaves were opened up to about 100 ft initially for the purpose of line construction, clearance being extended later to the required width of 200 ft or more. Straight-line clearances of up to 70 miles have been made. Bulldozers were employed to remove the small trees and brush which cover much of the countryside, as this method removes the roots and eases the problem of keeping the wayleaves clear in the future. In the north this work was



6 *Control and communication circuits*

a Telephone and photo-facsimile circuits
b Voice-frequency telegraph circuits

hampered by the presence of many large anthills—up to 100 ft in base diameter—which are hard to remove.

For lines as long as those required in Rhodesia, the only really satisfactory systems of fault protection are of the well known 'distance' class. The system adopted has the carrier-acceleration feature which enables faults at all points on long feeders to be cleared almost equally quickly. The selection of carrier frequencies for protection and communication which are capable of operating satisfactorily over the long sections and which can be co-ordinated to avoid interference between sections and adjacent systems, proved quite difficult.

Conventional differential protection has been used for the generators and reactors, while balanced earth-fault protection has been used for each winding of each of the 330 kV transformers, in addition to Buchholtz and winding-temperature relays. In all cases, back-up overload protection is used.

The provision of adequate means of control and communication over an extensive transmission system is a separate problem requiring much study. For the Federal Power Board's system, general communication will be provided by power-line carrier using telephone and voice-frequency telegraph apparatus, including teleprinters and photo-facsimile equipment. The arrangement of the communication and control channels is illustrated in Fig. 6. The main control centre is being established at Sherwood, and from here the Federal Power Board will also direct the operation of the associated thermal stations, under terms of reference similar to those of the old Central Electricity Board in Britain. At Kitwe there is an existing control centre for the 66 kV and 220 kV systems which will form a major satellite control, of particular importance in regulating the interconnection with the Belgian Congo.

Discussion

At the Supply Section meeting in the Institution building on the 30th April 1958, the paper describing the design of the 330 kV transmission system for Rhodesia was presented and discussed. Opinion was sharply divided on the merits of the choice of 330 kV, which is a standard, but not a preferred standard, voltage. Some speakers deprecated the introduction of a voltage between the 275 kV and 380 kV levels at present in use, whereas others pointed out that sparsely populated countries could not be expected to pay several million pounds extra merely to have a system at a preferred standard voltage. In fact, 330 kV systems are already as numerous as those at the two other voltages.

Some concern was expressed over the provision of important supplies along single lines for a number of years, since even if the fault outages were negligible there would have to be interruptions for maintenance and repairs. It was pointed out, however, that in the early years concerned a substantial reserve of thermal plant would be available in the receiving areas for planned outages, and the reliability of the single-circuit supply to the copper belt from the Belgian Congo had,

so far, proved well up to expectations. The tapering of the rates of growth of load in the later stages of the project was criticized, but a cautious policy in this direction has proved acceptable to the international bodies providing the finance for schemes of this sort, and there should be no difficulty in accelerating construction of the second phase of the scheme if actual load growth demanded it.

More than one speaker in the discussion expressed some envy of the opportunity given to the authors to consider a major transmission design unencumbered by much past development at lower voltages. Many speakers who were concerned with the provision of plant for the project were able to supply more detailed information on the characteristics of the equipment than the authors had been able to include in the limited space of the paper itself.

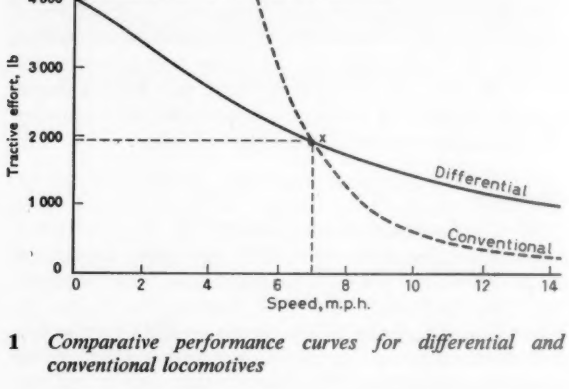
In presenting the paper the authors made extensive use of colour slides showing local conditions, and this method seemed to appeal to other speakers as many of them illustrated their remarks with similar slides, producing an unusually colourful evening.

CORRESPONDENCE

A NEW EPICYCLIC DRIVE FOR ELECTRIC LOCOMOTIVES

From H. E. J. SYMES, M.SC.(ENG.), ASSOCIATE MEMBER

IN reply to Mr. H. Charnley's letter in the August *Journal* (p. 436), the performance results obtained on test were not included in my paper* because of space limitation. However, the test curve for tractive effort and speed for the prototype is given by the solid line in Fig. 1 below. A satisfactory reply



1 *Comparative performance curves for differential and conventional locomotives*

to Mr. Charnley's assessment of the practicality of the drive needs some detailed explanation. By 'practical' he presumably refers to initial cost, installed power and space occupied, as related to output power.

First, the differential drive must be judged not in terms of the drive constants alone, but by its general use against the whole extensive and complex background of mining requirements throughout the locomotive's working life. The matter then narrows down to what we are prepared to do and pay to achieve improved service characteristics. It is common knowledge that conventional mining locomotives have a number of unsatisfactory and often dangerous features in their operation and design, as is shown by the troubles experienced and the accidents which have occurred. This is presumably the outcome of the early tendency 'to put the tramcar underground', which is not quite the correct solution for mine haulage.

A differential locomotive can always be built, at comparable cost, with a power output at least equal to, and usually greater than, that of a normal conventional locomotive of the same size and weight, especially when the rail gauge is narrow. It can be made shorter for a given performance, thus permitting a number of useful mechanical improvements for mining application. The prototype is 25% shorter than a typical equivalent conventional locomotive.

The dotted curve in Fig. 1 is for a standard locomotive of well known make, having a comparable rating but not provided with field-weakening facilities. The common point is at X, where both machines have a tractive effort of 1900 lb at 7 m.p.h., which can be regarded as their specified duty. For speeds greater than X, the differential machine develops considerably more power, and at low speed it has a tractive effort just below the wheel-slip point *without the necessity of working on the lower steps of the controller*. It thus has a more 'useful' characteristic for all-round duty, especially when driven by unskilled personnel. The relative positions of the two high-speed characteristics mean that the differential machine is capable of working more ton-miles per day where the route is predominantly level or only lightly graded. For trial purposes, the 6-ton prototype is temporarily doing the work of a 10-ton conventional unit in a South African mine. The argument still applies, but to a lesser degree, if the conventional locomotive is provided with field-weakening steps.

In practice, this feature means that, for a given haulage duty, the differential machine may have a smaller *nominal* rating, which reflects very beneficially on initial cost and size. Nor is the usual additional weight required to counteract the impulsive controller steps while accelerating.

Mr. Charnley's reference to inadequate acceleration is difficult to understand. Indeed, the very high rate of acceleration (and also of retardation) of the differential locomotive, particularly in the lower-speed motoring range, is one of its most outstanding characteristics. Without relying on the driver's skill, it is possible to achieve an almost ideal acceleration, i.e. one in which the tractive effort is continuous, non-impulsive and slightly below the adhesion limit. During the commissioning trials on the prototype it was reversed, without load, 16 times per minute and reached an appreciable running

* Reviewed in the April *Journal*, p. 189

speed in each direction. It has since been found that shunting and sorting of trains can be carried out with less severe buffing shocks in about two-thirds of the time normally required by a conventional, mechanically braked locomotive.

The installed machine capacity of the differential locomotive is about three times its output for long runs in one direction, or about 2¼ times for a short reversing shuttle service and shunting duty. If this be regarded as unpractical, then, in the same sense, so are all Diesel-electric locomotives (three times), Ward Leonard winders (3 to 3½ times, in thousands of horse-power), and the successful motor-generator locomotives of the Virginian Railroad in the United States. The drive has, in fact, many characteristics similar to those of the Ward Leonard system.

Briefly, the investigation reported represented an attempt to eliminate the more serious weaknesses of mining locomotives. Consequently, the paper was intended as an outline of the work done, a mathematical approach being used in an explanation of the operating experiences.

In the application of the differential locomotive to mining, its practicality and superior characteristics have been, and are still being, clearly demonstrated. The greatly improved braking qualities, actual and economic, would alone warrant its adoption in mines, quite apart from its many other desirable features. The cost of locomotive haulage is not restricted to initial outlay but also includes the expenditure on maintenance and operating labour. From the evidence so far available, routine maintenance on the differential unit promises to be far less costly and time-wasting than hitherto; and a lower-paid driver can be employed with success. The far greater popularity it enjoys among drivers is important for happy working in the mine.

A preliminary investigation shows that the drive permits battery locomotives to be used successfully in conditions which debar them at present, i.e. on heavily graded or undulating routes.

The equality of torque of the two motors, as mentioned by Mr. Charnley, is dealt with in section 8.1 of the paper.

Mr. Symes's letter was received on the 8th July, 1958

DEVELOPMENT OF ELECTRIC TRACTION

From R. D. REYNOLDS, ASSOCIATE MEMBER

IN Mr. L. Collins's excellent article in the June *Journal* (p. 289), *Some Notes on the Development of Electric Traction*, it is unsatisfactory to find special emphasis—and it occurs often—on the 'Diesel-electric locomotive' which is surely not really electric traction. In the article reference is made to 'other problems to be solved in applying electrical transmission to Diesel locomotives'. The two words 'Diesel locomotives' correctly describe them, whether the method of transmission be hydraulic, mechanical or electric.

If we regard railway routes as being electrified when Diesel (electric) locomotives take over from steam (which we must do if we bring them in under the heading of electric traction), we are surely getting ourselves into a state of confusion. Had electric transmission been adopted for the steam locomotive some years ago, would anyone have included this type of steam engine in the classification of electric traction? At one time a petrol bus was in use in this country which had electric transmission—it was known as the Tilling–Stevens petrol-electric bus. One wonders whether such a vehicle, if now developed with a Diesel (instead of a petrol) engine, would be regarded as a form of electric traction for our roads.

HISTORY OF ELECTRICAL ENGINEERING

From E. P. NYE,* ASSOCIATE MEMBER

WITH reference to this interesting series of articles, I would point out that in part 8 in the June *Journal* (p. 298) there was no reference to the Hastings undertaking, which was owned by the Hammond Company along with those of Eastbourne and Brighton.

Supply began from Hastings in March 1882, which I have always been given to understand was slightly before either the Brighton or the Eastbourne supply commenced. Since that date, the supply has been continuously available in Hastings: whereas in Brighton, and I believe in Eastbourne, there were short periods when it was discontinued.

Supply agreements are still in existence dating back to 1884. One such agreement, between the Company and the Hastings Pier Company, dated the 1st January 1884, refers to a supply of electricity for seven arc lamps from dusk to 11 p.m. on the Brush system for £175 per annum.

* Mr. Nye is with the South Eastern Electricity Board

COLOUR-TELEVISION TESTS

THE results of colour-television tests carried out by B.B.C. staff, in co-operation with the radio industry, up to the spring of 1957 are described* as 'promising', although further experimental work on equipment design is necessary. (An analysis of a further series of tests completed since then is now being made.)

The field trials extended over 17 months and involved the analysis of over a thousand questionaries filled in by B.B.C. staff and others who watched the results on special sets.

So far as reception of the colour picture is concerned, the B.B.C. consider that the American N.T.S.C. system as adapted to 405 lines, with the picture sources and display tubes at present available, is satisfactory. Registration with the 3-tube colour camera and certain features of the display tube still require attention, but the technical performance is adequate in the frequency bands now in use.

Test transmissions from Crystal Palace included live studio performances, film and slides. The reception of live scenes was regarded as satisfactory by 89% of the observers; of 35 mm film by 100%; of 16 mm film by 93%; and of slides by 98%. The reception of black and white transmissions on colour-television sets was found to be generally satisfactory, and 94% of technical observers found the black and white reception, on ordinary television sets, of colour transmissions completely acceptable.

The results of the tests have been sent to the Television Advisory Committee and to the C.C.I.R., which has recently met in Moscow to consider colour television. Many problems still require solution, however, including the production of a reasonably priced receiver and agreement on future standards to be applied to the development of television in the United Kingdom. The B.B.C. started experimental transmissions on 625 lines in black and white during May this year which are also part of the colour-television experiments.

The decision whether to supply a public service of colour television, and if so the choice of system, rests with the Postmaster General.

* B.B.C. Engineering Division Monograph No. 18: 'The B.B.C. Colour Television Tests: An Appraisal of Results'

Conference of Engineering Institutions of the British Commonwealth

At the invitation of the Australian and New Zealand engineering institutions, which had been extended and accepted at the previous meeting of the Conference held in London in May 1954, the Fourth Meeting of the Conference of Engineering Institutions of the British Commonwealth was held successively in Sydney, Melbourne and Canberra from the 19th March to 1st April 1958 inclusive, in ten sessions at which the following institutions were represented:

AUSTRALIA

The Institution of Engineers, Australia

Prof. D. M. Myers, B.SC., D.SC.(ENG.), M.I.E.AUST., M.I.E.E. (President)
Mr. H. G. Furphy, B.A., B.C.E., M.I.E.AUST., M.I.C.E. (Senior Vice-President)
Capt. G. I. D. Hutcheson, B.E., M.I.E.AUST. (Junior Vice-President)
Mr. D. V. Darwin, M.M., M.C.E., M.I.E.AUST., M.I.C.E. (Past-President)
Mr. R. W. J. Mackay, B.SC., M.E., B.EC., M.I.E.AUST., A.M.I.E.E. (Past-President)
Mr. C. H. D. Harper, M.C., M.I.E.AUST. (Secretary).

CANADA

The Engineering Institute of Canada

Mr. C. M. Anson, B.SC., M.E.I.C. (President)
Dr. I. R. Tait, B.SC., M.E.I.C. (Vice-President)
Dr. L. Austin Wright, B.A.SC., M.E.I.C., M.I.C.E. (Secretary)

CEYLON

The Institution of Engineers, Ceylon

Observer: Mr. S. Rajanayagam, O.B.E., B.SC.(ENG.) (Honorary Secretary)

INDIA

The Institution of Engineers (India)

Mr. D. P. R. Cassad, B.SC., M.SC.(ENG.), M.I.E.(IND.) (President)
Mr. B. Seshadri, B.SC., M.SC.(ENG.), M.I.E.(IND.) (Secretary)

PAKISTAN

The Institution of Engineers, Pakistan

Observer: Mr. M. A. Jabber, M.I.E.(PAK.) (Vice-President)

NEW ZEALAND

The New Zealand Institution of Engineers

Mr. W. G. Morrison, O.B.E., B.E., M.N.Z.I.E., M.I.C.E. (President)
Mr. D. L. Bedingfield, LL.B., A.R.A.N.Z. (Secretary)

SOUTH AFRICA

The South African Institution of Civil Engineers

Prof. J. E. B. Jennings, B.SC.(ENG.), S.M.(ENG.), M.(S.A.)I.C.E., M.I.C.E. (President)

The South African Institution of Mechanical Engineers

Mr. D. A. Dallamore, B.SC.(ENG.), M.(S.A.)I.MECH.E., A.M.I.C.E., M.I.MECH.E. (President)

Delegates to the Commonwealth Conference at Science House, Sydney, the Headquarters of the Institution of Engineers, Australia
left to right: FRONT ROW: I. R. Tait (Canada), Prof. J. E. B. Jennings (S.A.I.C.E.), M. A. Jabber (Pakistan), T. E. Goldup (I.E.E.), Sir Arthur Whitaker (I.C.E.), W. G. Morrison (New Zealand), Prof. D. M. Myers (Australia), D. P. R. Cassad (India), C. M. Anson (Canada), M. Hewitson (S.A.I.E.E.), D. A. Dallamore (S.A.I.M.E.), H. G. Furphy (Australia)
MIDDLE ROW: C. H. D. Harper (Australia), B. G. Robbins (I.M.E.), S. Rajanayagam (Ceylon), R. W. J. Mackay (Australia), W. K. Brasher (I.E.E.), B. Seshadri (India), Capt. G. I. D. Hutcheson (Australia), D. L. Bedingfield (New Zealand), L. Austin Wright (Canada)
BACK ROW: A. McDonald (I.C.E.), D. D. N. McGregor (Australia), A. J. Adams (South Africa)

The South African Institute of Electrical Engineers
Mr. M. Hewitson, M.(S.A.)I.E.E., M.I.E.E. (President)

The South African Institution of Civil Engineers
The South African Institution of Mechanical Engineers
The South African Institute of Electrical Engineers
Mr. A. J. Adams, HON.M.(S.A.)I.E.E. (Joint Secretary for the three South African Institutions)

UNITED KINGDOM

The Institution of Civil Engineers
Sir Arthur Whitaker, K.C.B., M.ENG., M.I.C.E. (President)
Mr. A. McDonald, B.SC., M.I.C.E. (Secretary)

The Institution of Mechanical Engineers
Mr. T. A. Crowe, M.SC., M.I.MECH.E. (Past-President)
Mr. B. G. Robbins, M.SC.(ENG.), M.I.MECH.E. (Secretary)

The Institution of Electrical Engineers
Mr. T. E. Goldup, C.B.E., M.I.E.E. (President)
Mr. W. K. Brasher, C.B.E., M.A., M.I.E.E. (Secretary)

As has been the case at previous meetings of the Commonwealth Engineering Conference, its business sessions were devoted to the discussion of a number of matters of interest to the constituent institutions, their members and the public whom they serve.

Although representatives of the Rhodesian Institution of Engineers were not able to be present on this occasion, the findings of the Conference will be considered by the Council of the Rhodesian Institution of Engineers, who will communicate their views to the Conference Secretariat in due course.

At the outset, the Conference welcomed the presence of observers from the Institution of Engineers, Ceylon, and the Institute of Engineers, Pakistan—societies which, as a result of a decision taken by the Conference, will now receive invitations to become permanent members.

Professional Training

In the ensuing deliberations, much emphasis was placed on the importance of accurately estimating the future demand for professionally qualified engineers throughout the Commonwealth, and also on the measures which it would be necessary to adopt to satisfy this. In considering this question, the Conference took note of corresponding discussions which had taken place at the Conference of Engineering Institutions of Western Europe and the U.S.A. (Eusec) in September 1955; a close community of outlook between the two Conferences was evident.

Much attention was paid to problems concerned with the education and training of professional engineers. The requirements of the constituent institutions as they concern entrance standards, the examinations held by the institutions and exemption therefrom, and the requirements as to the practical training of candidates, as specified by the various institutions represented, were compared and discussed. Consideration was also given to the part which employing organizations could play in assisting engineering students and in helping teaching organizations, as for example by the part-time release of students and by the encouraging of senior engineers to be prepared to undertake lecturing and teaching work on a part-time basis.

Advanced (post-graduation) courses for engineers were examined, and interchanges took place on the policies of the various institutions in respect of such courses on engineering subjects on the one hand, and in management subjects on the other. At one of the sessions, the representatives exchanged views on the present practices and experiences of their institutions in the field of public relations; they also reviewed the relations of their institutions with associations for engineering technicians operating in their territories, and in particular the steps which some of them had taken to stimulate the founding of such associations.

Relations with Other Societies

At the next session, the Conference considered its relations with other international organizations in the engineering field, such as the Union of International Engineering Institutions (U.A.T.I.).

Following the attention which had been given to the matter at its meeting in London in 1954, the Conference devoted further study to the action to be taken by the constituent institutions in stimulating among their members an appreciation of the need to conserve national resources, and they discussed means for co-ordinating the efforts of engineers to this end. The Conference also surveyed the impact of new techniques and developments on existing engineering institutions and noted with interest the steps which had been taken in Great Britain to co-ordinate interest in the nuclear-engineering field through the creation of the British Nuclear Energy Conference and, in another growing field, by the establishment of the British Conference on Automation and Computation. Finally, the Conference examined the role of the constituent institutions in the promotion of research.

The outcome of the foregoing deliberations was expressed in 15 recommendations which are now under consideration by the Councils of the constituent institutions, and in the form of 13 resolutions in which are set out decisions of the Conference in respect of its own proceedings and future work. The texts of the recommendations, accompanied by the Conference resolutions, will be published as soon as they have been ratified by the Councils of the constituent institutions.

Social Engagements

In addition to the business meetings, the delegates were entertained in both Australia and New Zealand at a number of social engagements having the main object of bringing them into contact with many of the leaders of the two countries, and also to let them see examples of the notable engineering works which were in progress

in these lands. All the visiting delegates were greatly impressed by the warmth and extent of the hospitality they received and by the boldness of conception of the engineering projects they visited, in both Australia and New Zealand. Reference might be made to the visit paid in Australia to the Snowy Mountains Scheme and in New Zealand to the works of the State Hydro-Electric Department and the development of geothermal power at Wairakei. The arrangements made by the hosts for the comfort and interest of the delegates were on all occasions beyond praise, and the successful plans made for the separate entertainment on a number of occasions of the ladies of the party were greatly appreciated.

Another memorable event was the concluding Conference dinner at the Hotel Canberra, on the 31st March, when representatives of the visiting delegations spoke of their great satisfaction with the results achieved by the Conference, offered their congratulations to the host institutions on the arrangements made for the conduct of Conference business, and expressed their gratitude for the unforgettable experiences enjoyed in the social sphere.

THE PUZZLE OF POYNTING'S THEOREM 621.3.013

When Mr. P. Hammond prepared his work on 'Electromagnetic Energy Transfer', which was published under that title as Monograph No. 286 in February this year, Prof. Moullin was intrigued to find that his junior colleague had, independently, picked up his own long-established doubts about Poynting's theorem and managed to resolve them. The present article gives an account of the development of personal understanding about a knotty point of electrical science. Prof. Moullin is Professor of Electrical Engineering in the University of Cambridge.*

PROF. E. B. MOULLIN, M.A., SC.D.,
PAST-PRESIDENT

ALTHOUGH familiarity may breed contempt, there must be many electrical engineers to whom wireless transmission remains a subject full of mystery. On the face of it, at least, it is easier to understand how a signal can be sent along a transmission line. Engineers long to 'connect up' between the sending and receiving ends. But in radio work there is a baffling gap between the transmitter and the receiving aerial.

In spite of much loose talk about waves (in a non-existent aether?), many of us are baffled. This is all the more surprising when it is remembered that in 1884 and 1885 J. H. Poynting published two famous papers, in which he claimed to have found a satisfactory solution to the problem of energy transfer without wires. Poynting firmly believed in Maxwell's all-pervading aether, and the wires used by electricians to connect their apparatus were to him a mere thickening in that aether. To talk of currents flowing along wires was to him to adopt an old-fashioned view: the real action took place in the space between the wires. In fact, even a simple direct current had to be explained in terms of wireless transmission.

With all this in mind I was intensely interested to see a recent Monograph (No. 286) by my young colleague, Mr. P. Hammond. The title, *Electromagnetic energy transfer*, carries with it a strong echo of Poynting's first paper, *On the transfer of energy in the electromagnetic field*. My difficulties with Poynting's theorem date back to about 1910. In early days these difficulties caused me so much trouble that eventually I decided to give up the use of Poynting's method in its direct form. Knowing all the background of it in my own mind, this seems still to have been reasonably wise.

In acknowledging my 'unfailing encouragement' Mr. Hammond might well be taken to imply that I had pointed out this problem to him explicitly and mildly nagged at him until he had completed it. In this sense, his statement is untrue and misleading. He thought of the subject himself, and I heard nothing of his work until he showed it to me in its complete form. On the other hand, it is true that this problem had been very much in my mind for the last 48 years. By close association he has probably caught, by a kind of subconscious infection, many of the troubles which were tacitly in my mind. This being so, it may well be worth-while for me to record now an outline history of mental battles since my undergraduate days, or over about the last half-century.

Early Notions

To an enormous degree I began to pick up my mental concepts of electricity as a wireless amateur about 1910. I think I gathered my early notions of radiation resistance from Fleming's Manual* about that time: though my youthful thoughts were very vague and muddled, yet the general idea had started to exist. I believe I met Poynting's theorem when working for the Tripos in 1915, or at any rate from Jeans's treatise,† my first serious electrical book:

* Monograph No. 286 is republished this month in Part C of the *Proceedings*, p. 352; a synopsis appeared in the February *Journal*, p. 98

* FLEMING, J. A.: 'An Elementary Manual of Radiotelegraphy and Radiotelephony' (Longmans, Green, London, 1908)
† JEANS, J. H.: 'The Mathematical Theory of Electricity and Magnetism' (Cambridge University Press, 1908)

more particularly, however, from Starling's book*—and that at a time when my Tripos studies had started to put order and system into my mind.

I have a very definite recollection of being told that all the real activity was in the empty space between the wires of the receiving sets which I made: and an equally clear recollection of mental distaste at this idea. The 1914–18 War confiscated my wireless gear and my aerials, and my wireless ideas had to be suspended and replaced by thoughts about dynamos and a.c. motors. As soon as I was allowed to use aerials again my thoughts flooded to them, and I was confronted very seriously with Poynting's theorem. General ideas of aerials did not appear to be illuminated at all by my, then reasonably developed, student's knowledge of a.c. circuits. These ideas brought me helpfully to the aerial terminal, but thereafter was an unknown territory until the terminal of the receiving aerial was reached.

I sought help from my mathematical colleagues, who told me it was all contained in Maxwell's equations. Of this I had no doubt, but gradually it dawned on me that they really knew no more than I did how to trace the problem, step by step, through Maxwell's equations. I was told to read Oliver Heaviside. This I did studiously, and with great faith, during the years 1921–24, finding perpetual use of Poynting's theorem, or its equivalent. But Heaviside's work seemed to me like deliberate 'thriller writing', in which the real answer must surely be in the next chapter, and so on indefinitely. Finally, I came to the conclusion, I still think rather soundly, that of Heaviside I would have no more; doubtless it was due to my own clumsy incompetence as a mathematician.

Rugby Enigma

Meanwhile, I bothered my friend and colleague, Dr. L. B. Turner, for help. At that time his mind was much occupied with the construction of the great Hillmorton Station at Rugby; and I was therefore impelled to think much about its gigantic aerial of vast area. Appeal to classic works confronted me only with Hertz dipoles: how was I to be satisfied that the Hillmorton aerial was properly represented by a Hertz dipole? The answer seemed to be to perform an integration over a sphere so large in diameter that the Rugby aerial shrank to a mere, almost formless, speck at the origin. This was seemingly a sad get-away from reality for the constructing engineers who had achieved this vast structure. Poynting's method was doubtless very clever, probably valid, but terribly unconvincing about the mechanism. Dellinger's pamphlet, from the Bureau of Standards, approached the problem in a much more direct way, which seemed helpful. This led me, through Pidduck's treatise, to the Lorentz force equation. Here was something to which I wanted to cling: and I have clung to it tightly ever since. Work was being put into the aerial, and hence there must be a mechanism which made it harder to drive the current into the aerial. The old concepts of back-e.m.f. of a motor appeared at once in my mind. If I could calculate that back-e.m.f., along the aerial wire, there would be an approach which would be real, in a sense that the Poynting calculation was not real to me.

Simultaneous Publication

During the summer of 1928 I succeeded and was much comforted by finding that my method yielded the same numerical result as Poynting's method had done: if he was right, then so was I. My method was published in the *Proceedings of the Cambridge Philosophical Society* in 1929. A month or two earlier, Pistolkors had his famous paper* published by the Institute of Radio Engineers. Clearly, it was basically the same kind of approach.

Certainly it was the conscious search for the equivalent of the back-e.m.f. of a motor which led me to look for the result which I ultimately found. At that time I was certainly clear that, in a motor on open-circuit, there must be a distribution of charge on its armature winding whose presence would produce the electric force which would make the net force zero at all points along the conducting winding: a point which is tacitly ignored in all conventional treatments. Thus, that my concept of back-e.m.f. of radiation appeared to state that the electric force was not zero at all points along the aerial wire was not necessarily a gross error, but was an incompleteness, which had always been tolerated in the analysis of machines. I was working out what would occur for an assigned current and charge distribution: recognizing that the discovery of the exact distribution was not of primary importance in the radiation aspect of the problem. Or, in other words, the incorrectness of the assumed current distribution would make a negligible change in the input of power to the aerial. As opportunity offered, I made approximate estimates of the magnitude of this error and found, as expected, that it was indeed negligible. Some of the more complete of these estimates can be found in my book *Radio Aerials*, particularly in chapter 8.

Conclusion

Most of the points raised in these comments can be found, explicitly or implicitly, in Mr. Hammond's paper.

He has not solved the problem of energy transfer, and he has shown that Poynting had not solved it either. But he has removed a lot of the obscurities surrounding Poynting's method and has shown how and why that method can be employed in calculation. He has shown that the dynamo designer and the designer of radio aerials are closer to one another in outlook than some of them may have guessed. As always, electrical science is seen to be a coherent whole.

* STARLING, S. G.: 'Electricity and Magnetism for Degree Students' (Longmans, Green, London, 1912)

* PISTOLKORS, A. A.: 'The Radiation Resistance of Beam Antennas', *Proceedings of the Institute of Radio Engineers*, 1929, 17, p. 562

THE METHOD AND PROGRESS OF ELECTRIFICATION IN BURMA

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In early 1954, only 31 towns in Burma had an electricity supply, and the Government of the Union decided on an ambitious scheme to construct a national network within a very few years. An impressive feature of its success so far is the ready co-operation of local townsfolk and villagers, and in this article the author gives a graphic account of how this was obtained. Mr. Tin is with the Union of Burma Electricity Supply Board, Rangoon.

R. TIN, A.M.I.E.AUST., ASSOCIATE MEMBER

THE Government of the Union of Burma, having realized the need for raising the standard of living of the people and of relieving Burma's dependence upon imported manufactured goods, decided to institute a vigorous programme of electrification which was planned to take place in three stages:

(1) Electrification by small independent Diesel stations
(2) Electrification by large strategically placed Diesel stations with 33 kV and 11 kV networks taking over the load from the small Diesel stations, whose generating sets would be moved to isolated areas
(3) Electrification by hydro-electric power stations with a 230 kV and 132 kV primary transmission system taking over the load from the big Diesel stations, which would either be retained as standby or sent to areas not covered by the main network.

Stages 1 and 2 were designed to increase the demand for electricity progressively so that when the first hydro-electric station of stage 3 was completed a market would exist for the power it produced.

Thus it became necessary for the Union of Burma Electricity Supply Board (E.S.B.) to construct in a few years a network such as had taken other countries decades to evolve.

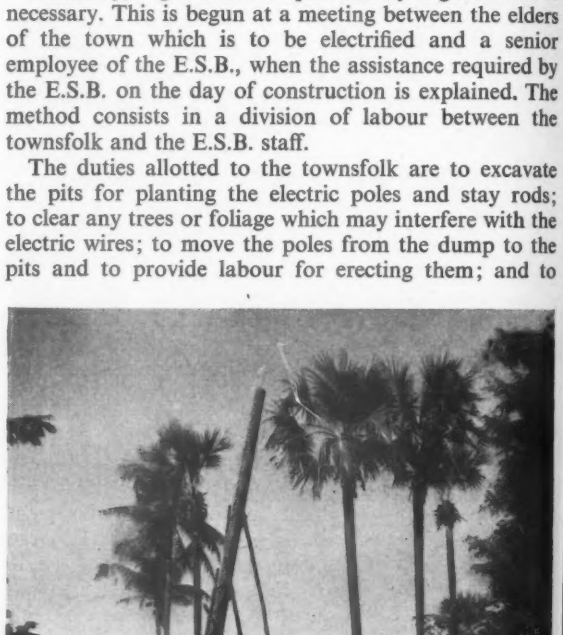
At the beginning of 1954 there were only 31 towns with an electricity supply, and of these, in only three was the supply available for the full 24 hours, the others being operated exclusively during the night. No village had electricity. Today there are 323 towns and 349 villages with electricity, of which 70% are supplied on a 24-hour basis. All the significant towns in the country have now been electrified, and more villages and small towns are being connected up at a rate of about 16 a month, the objective being to make electricity available to all the towns and villages in Burma.

Constructed in a Day

This rate of growth has been made possible by the development and adoption of a method of electrifying towns known locally as the 'one-day scheme'. The method was introduced by Major Tun Tin, past Chairman of the E.S.B., and is so called because it enables the construction of the whole l.v. distribution system of a sizeable town of up to 50 000 inhabitants to be completed in 24 hours. The key to this method lies in invoking the full assistance of the townsfolk concerned.

Naturally, a good deal of preliminary organization is necessary. This is begun at a meeting between the elders of the town which is to be electrified and a senior employee of the E.S.B., when the assistance required by the E.S.B. on the day of construction is explained. The method consists in a division of labour between the townsfolk and the E.S.B. staff.

The duties allotted to the townsfolk are to excavate the pits for planting the electric poles and stay rods; to clear any trees or foliage which may interfere with the electric wires; to move the poles from the dump to the pits and to provide labour for erecting them; and to



Erecting a pole

provide labour for tensioning the wires and for general purposes.

The functions of the E.S.B. staff are thus to survey the town and to do the alignment and pegging for the poles and stay rods; to fit the insulators, clamps, braces, cross-arms and other items to the poles as necessary; to erect and align the poles; to pay out, string and tension the wires and finally bind them on the insulators; and to fit the street lights and connect up the service mains to the consumers.

Liaison Committee

Next, the elders are requested to form an electrical advisory committee of nine members representing the administrative, political, security and other major organizations in the town. The purpose of the committee is to assist and safeguard the interests of the E.S.B. and to advise on all non-technical matters pertaining to the supply of electricity. After the meeting this committee provide the liaison between the town and the E.S.B. and are particularly valuable in the critical period before the actual electrification.

One of the first duties of the committee is to make available a site for the power house and future buildings of the undertaking. Usually a site of about two acres is required, and it is not surprising how this committee, comprising the most influential people in the town, promptly produce a site, near the load centre, which would in other circumstances be almost impossible to obtain. Further, it being the policy of the E.S.B. to train and utilize, as far as possible, local staff to run the supply undertaking, the advice of the committee on the capability and character of the various applicants is invaluable, and their recommendations are usually accepted. Normally the committee meet every month, and a new committee is elected every two years.

After the staff have been selected they are trained in all aspects of their work at a school specially set up for the purpose by the E.S.B. The course usually takes eight months, but if a town happens to be electrified before its own men are trained, a temporary crew drawn from nearby towns is used during the interim. Conversely, if a crew has been fully trained but their town not yet electrified, they may be sent to work in towns whose staff are not yet ready.

Friendly Rivalry

As soon as the site has been obtained, construction of the simple three-roomed building comprising the office, store and engine room is proceeded with. Depending upon the availability of materials and accessibility of the town, a date for the electrification is set and the materials are dispatched. On the eve of the appointed day, the E.S.B. staff of all the towns in the area are assembled and accommodated in a suitable place such as the school or town hall. Here a centre of operation is set up and temporary telephone communication laid on, and if the Chairman of the E.S.B. is present to direct the work, radio communication with the headquarters in Rangoon is also installed. A detailed briefing is now given to the men, and a film made during the electrification of another town is shown to familiarize them with the work. Meanwhile a similar film show is being given in the open air to the townsfolk, accompanied also by information and newsreels. The men are divided into self-contained groups, and each group is given full responsibility for the completion of a section of the distribution system. The friendly rivalry between these groups has the added advantage of acting as an incentive for one group to complete their section before the others and further ensures completion of the work within the day. Usually the townsfolk work with the group in whose section their homes lie.

Unloading poles and a generating set at a riverine town

Work begins at dawn and continues until the whole distribution system is completed. Sometimes the job is finished by sundown, but occasionally it has to continue until the small hours of the morning, by the light of lorry headlamps and electric torches. All the while, encouragement and music are being disseminated by loudspeakers and dancing troupes in lorries, in each of which there is a co-ordinator keeping an eye on progress and straightening out difficulties immediately.

Blaze of Light

Simultaneously with the construction of the overhead lines, groups of electricians are installing the internal wiring in the houses, while a party of Diesel mechanics

are fitting up the generating sets in the engine room if it has been finished, or in a temporary shed if not. As street lighting on alternate poles is given free for a month, for publicity purposes and in appreciation of the townsfolk's assistance, the blaze of light as it is switched on is a gratifying sight after a day's hard work.

In no instance has the response from the townsfolk been unsatisfactory. On the contrary, while the men are enthusiastically doing the heavy work, the women invariably prepare and serve food and refreshments to the whole work force, which may number anything up to 500.

In electrifying a village only the scale of work differs; the method is the same. Or, if the source of supply is to be from an h.v. line, a pole-mounted transformer is erected in place of the Diesel generating set.

Geographical Parallel

The geography of Burma is such that the main communications run in an almost straight line from north to south, and consequently all the important towns lie along this line; while the secondary towns are situated on branches running off either to the east or west of the main artery. In consonance with this pattern, 33 kV lines have been built which radiate approximately north and south from the big Diesel stations to feed frequent 33/11 kV substations. The 11 kV feeders radiate in all directions from these substations, but particularly east and west to take in all the towns which first received their electricity from the small Diesel generating sets. The main 230 kV line is being built parallel to the main roads and will feed substations which will take the place of the big Diesel stations of stage 2.

So far, 1194 miles of 11 kV line and 15 miles of 33 kV line have been built departmentally by orthodox, if high-pressure, methods. Contractors have completed 461 miles of 33 kV line and are at present working on 250 miles of 230 kV line, whose completion in early 1960 should coincide with the first stage of the first hydro-electric station, when 84 MW of power will become available. In the meantime, there are 42 MW of steam generators and 43 MW of Diesel generators in commission, while plans are proceeding apace for a 132 kV transmission line, and other hydro-electric projects are being studied.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated.

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

Radio Research 1957. The Report of the Radio Research Board and the Report of the Director of Radio Research. London, H.M.S.O., 1958. 3s. 6D. (postage 4D.)

PROPOSALS made in this Annual Report include further development of measuring techniques of secondary-standard calibre up to the highest radio frequencies, investigations into molecular amplifiers and oscillators, and basic research on microwave aerials to achieve economical use of the r.f. spectrum.

PERGAMON INSTITUTE

Russian Translation Journals

MANY electrical engineers will have heard of *Elektrichestvo*, the long-established Russian electrical engineering journal, which a year or two ago celebrated its 75th anniversary. The journal is concerned primarily with heavy electrical engineering, in certain aspects of which the U.S.S.R. is now in the front rank. Much development work has been done on d.c. power transmission, associated rectifier and inverter equipment and supervisory controls. In another field noteworthy contributions are being made to the theory of automatic and remote control, and the standard of theoretical and mathematical work is high.

Until recently it has been very difficult for electrical engineers to familiarize themselves with the contents of *Elektrichestvo* unless they could read Russian. Now, however, an English translation of parts of this Russian journal is being published by Pergamon Press Ltd. for the Pergamon Institute (described as 'a non-profit-making foundation'). The decision to publish this translation has been reached with the support of many electrical engineers in Great Britain and the United States; a number of the professors of electrical engineering in British universities are on the advisory board guiding the translation of the journal. The translation journal, which is entitled *Electric Technology U.S.S.R.*, is to appear four times a year and will contain a selection of the most important papers appearing in the complete Russian version. The first issue, dated May 1958, contains translations of 16 articles out of the 70 contained in Nos. 1 to 4 (1957) of *Elektrichestvo*; future selections are expected to amount to about 50% of the whole.

In addition to the above, complete 'cover-to-cover' translations of three other Russian electrical journals are being published by the Pergamon Press. These are *Radio Engineering and Electronics U.S.S.R.* (a translation of *Radiotekhnika i Elektronika*), *Radio Engineering U.S.S.R.* (*Radiotekhnika*) and *Telecommunications U.S.S.R.* (*Elektrosvyaz*). These are being produced in association with the Massachusetts Institute of Technology, with financial support from the United States National Science Foundation.

An English edition of *Fizika Metallov i Metallovedenie*, entitled *The Physics of Metals and Metallography*, is also being published by the Pergamon Press, on behalf of the Board of Governors of *Acta Metallurgica* and with the financial support of the National Science Foundation and the United States Atomic Energy Commission.

Those who are interested in subscribing for the translations or obtaining further information should write to the Pergamon Press, 4–5 Fitzroy Square, London W.1.

FREE AND BOUND ELECTRONS

A Report on the Microwave Valve Convention

An international convention on microwave valves was held in the Institution building during the week beginning the 19th May 1958. This report describes the happenings at the 20 sessions, at which 126 papers and contributions, from many countries, were presented (listed in the June Journal, p. 306). Most of the papers, contributions and discussions will be published in due course in Supplements to Part B of the Proceedings of The Institution.

Security restrictions during and since the recent war caused workers in this sphere to become isolated from one another. Lately there has been a relaxation of these restrictions, and the convention was of great value in bringing together those concerned for the discussion of problems and the exchange of ideas in this rapidly expanding field.

A CONVENTION lasting a week is no mean undertaking, and the Radio and Telecommunication Section may be congratulated on the success attending that on microwave valves which they organized on the 19th to 23rd May. Over 700 delegates registered for the convention to hear some 126 papers and contributions presented and discussed. The international aspect was emphasized by the presence of representatives from Australia, Austria, Canada, France, Germany, Hungary, Italy, Japan, the Netherlands, Norway, Poland, the Soviet Union, Sweden, Switzerland, and the United States.

With so many delegates and so many papers it was necessary to use the procedure of parallel sessions. Fortunately, in this case, the parallel sessions could be limited to two, so that in general delegates had little difficulty in choosing that which lay closer to their own work.

As a general background to the papers and contributions, particularly for those members not closely in touch with the field, an exhibition of microwave valves and allied components of research and development interest was arranged in the Council and Tea Rooms. The week's work and pleasure were aided by a social programme which included a visit to a fashion show arranged for delegates' wives.

Dr. R. Cockburn, C.B., O.B.E., M.Sc., Ph.D., Member, Controller of Guided Weapons and Electronics, Ministry of Supply, delivering the Introductory Lecture

The convention was opened on the Monday morning by the President, who had just returned from his extensive oversea tour; and in his opening remarks he indicated that he felt particularly qualified to extend a welcome to those who had travelled from oversea to participate. He emphasized the significance of events of this kind, bringing together men of like minds working in a common field throughout the world to share their ideas and widen their experience.

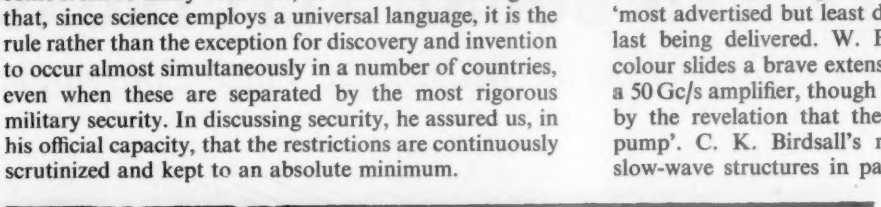
The President then introduced Dr. R. Cockburn, Controller of Guided Weapons and Electronics in the Ministry of Supply, and invited him to deliver his introductory lecture, 'Microwaves in Science and Technology'.

Universal Language

In his foreword, Dr. Cockburn defined generally the scope of the convention—the generation and amplification of microwaves, the wavelengths embraced being within the somewhat arbitrary band 30 cm to 0·1 mm. He listed the devices covered, including the magnetron, the klystron, the travelling-wave tube, the backward-wave oscillator, Cerenkov radiators, gas-discharge valves, and atomic and molecular generators. He coupled the list with the physical aspects of this subject, such as electron field interaction, plasma oscillations, slow-wave structures, resonator electron optics, thermionic emission and solid-state physics.

In pointing out that contributions in this branch had

come from so many countries, he reminded the delegates that, since science employs a universal language, it is the rule rather than the exception for discovery and invention to occur almost simultaneously in a number of countries, even when these are separated by the most rigorous military security. In discussing security, he assured us, in his official capacity, that the restrictions are continuously scrutinized and kept to an absolute minimum.



A view of some of the exhibits in the Council Room

Taking as his starting point the interest of chemists and physicists at the beginning of the century in extending spectroscopy into the far infra-red, he pointed to the various steps taken to generate oscillations at these very short wavelengths. It is not generally known that as early as 1896 a spark oscillator was used to generate waves of 0·6 mm wavelength. The long period up to the start of the recent war was taken up in evolving valve-like devices capable of generating considerable power with good efficiency, and this was followed by the period of exploitation during the war when microwave radar and communication grew at an outstanding rate and provided the forces for further work on valves. The end of the war saw a stimulus to the original forces which had started the process, and great advances were made in physics, particularly in the study of the solid state. Now we see solid-state devices being made available for further exploitation of microwaves and advances in microwave techniques.

And what of the future? Dr. Cockburn closed his study with a note of optimism coupled with a word of caution. The applications of microwaves are so wide-spread, extending in range from cosmic observations with radio telescopes to the fine structure of matter revealed by microwave spectroscopy, that there is a real danger of dissipating effort in unnecessary duplication and minor refinement. With this warning in mind, he felt there was every reason to expect evolution of the whole field to continue with increasing momentum.

The Tube Delivered

The technical forum of the convention opened in the afternoon with session 2, which, with session 4, was devoted to travelling-wave tubes. It appears that the 'most advertised but least delivered tube in history' is at last being delivered. W. E. Danielson described with colour slides a brave extension of the use of the helix in a 50 Gc/s amplifier, though little surprise was engendered by the revelation that the first tube was 'still on the pump'. C. K. Birdsall's results of using numbers of slow-wave structures in parallel, showing that as more structures are used the size of the structure must be reduced, were felt to reveal yet another facet of a well known law. Other attempts to overcome the limitations of a single helix were given in the paper of G. M. Clarke, who produced some surprising results from water-cooling, and in that of J. D. Pearson, who described a tube using the ring-and-bar structure derived from a cross-wound helix. Over-all, however, the helix still appears to be holding its own, and the pulsed power output of 1 kW obtained from a broad-band pulsed X-band amplifier was not felt to be the upper limit.

The magnetron, the first successful microwave source of high power, was also covered early in the convention, in session 3. Progress is towards obtaining higher peak-power outputs. H. A. H. Boot gave a most interesting account of results achieved by increase of axial dimensions, indicating that at least 5 MW peak power may be obtained in this manner at 10 cm wavelength. R. Zwobada had developed a valve giving 200 kW peak output at a wavelength of 8·6 mm. A new aspect of the theory of circular magnetrons, presented by R. Dunsmuir, was particularly welcome in a field where practice has often been in advance of theory.

Colour Film

The end of the first day's programme saw the first of the week's informal social events. An assembly of 370 delegates and their ladies gathered in the Library and Common Room for cocktails and conversation. The renewal of old acquaintanceships, and the starting of new ones, proceeded with vigour until the turning down of lights reminded those still talking that a full programme lay ahead next day.

On Tuesday, well-attended sessions were devoted to the older and less glamorous devices such as gas-discharge valves and grid-control valves. While gas-discharge cells have been used as duplexers since the earliest days of radar equipment, it was clear that finality in the design of these devices has not yet been reached. The necessity for increase in average cell life was mentioned by a number of speakers, and techniques were described which should further this objective. Other uses for gas-discharge plasma are arousing interest, as, for instance, the modification of the propagation characteristics of waveguides, explained by R. W. Gould. This has several microwave applications, including the measurement of electron densities in thermonuclear apparatus.

An excellent method of presenting a paper on a mechanical development was introduced in session 7 by A. E. Widdowson, whose contribution on grid-making techniques took the form of a colour film, with sound. In this session, too, M. V. Hoover described the impressive development of u.h.f. triodes and tetrodes with c.w. outputs of tens of kilowatts and pulsed outputs of hundreds of kilowatts.

Remarkable Machining

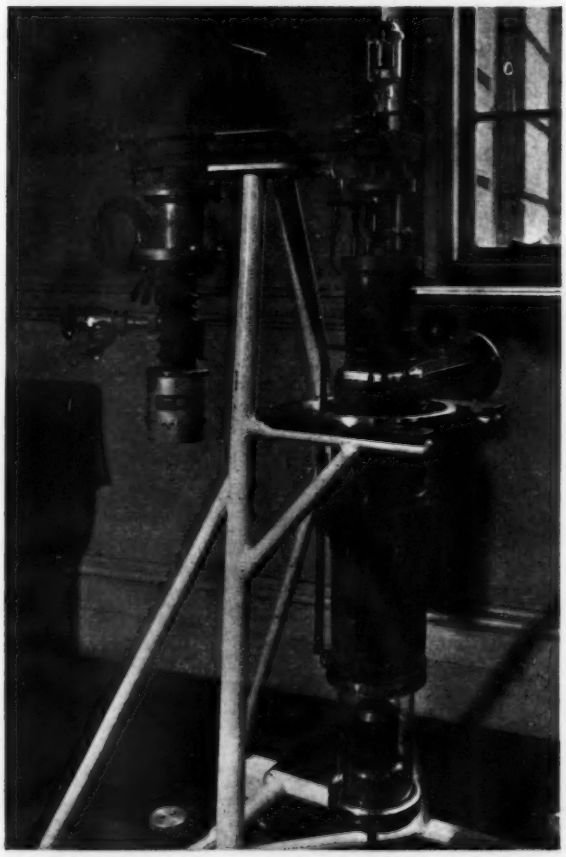
Sessions 6 and 8 dealt with backward-wave oscillators. B. Epsztein presented some very pretty experimental results showing the spoke formation in a crossed-field tube. In his analogue he examined the beam as seen by an observer travelling along with the velocity of the electron stream. The effect of increasing r.f. field was elegantly displayed. C. K. Birdsall introduced a new type of interaction in the so-called M-J tube. The J represents the operator j, since this tube employs the r.f. structure in a plane at right angles to that in the usual M-type, i.e. the structure is along the sides of the beam instead of at the top. His hope was to produce a mechanism giving the gain of an O-type valve with the efficiency of the M-type, but without the disadvantage of electrons hitting the slow-wave structure. There were a number of other papers dealing with M-type devices, but for the paper by G. Boucher on technology of carcinotrons we had to wait until the Friday owing to the 'situation' in France. The wait was well worth while as he reported the construction of an M-type oscillator giving 20 W in the 8 mm band. The extremely small dimensions involved represented a remarkable piece of machining to carry out in copper.

A paper by Z. S. Chernov was added in session 8. The reading of this paper was a combined operation involving three people: Dr. Chernov read the title and summary in Russian, and he was followed by Mr. A. F. H. Thompson who read an English translation of the paper. A lively discussion followed, which was very ably translated by Mr. S. H. Taylor. The paper described first the 'spiratron', which is a travelling-wave tube employing centrifugal electrostatic focusing. The tube operated over a 3:1 bandwidth with high efficiency even down to very small currents. The second device reported was an 'antiklystron', in which a similar spiral beam was bent round into a torus to form an electron resonator. If a gap was left in the outer sheath, interaction could be obtained with a fast wave passing through the torus. This device had been shown to amplify and oscillate, tuning over a 2:1 band of frequencies.

The development of microwave valves is largely bound up with the technology involved in their construction, and this was reflected in the large audience for session 9. One limiting factor in high-power valves is the power-handling capacity of the window, and a number of papers were presented giving details of different types of ceramic window. Particularly interesting was the account by J. B. Lebacqz of his experience with windows to transmit multi-megawatt power.

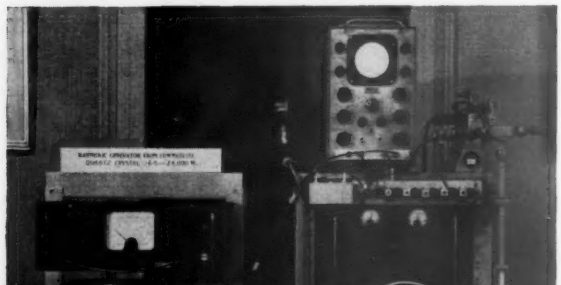
Mainly Theoretical

Apart from D. J. Harris's paper on the experimental measurement of the 'diocotron' effect, session 10, on space-charge waves, was largely for the theoreticians. In this field, C. C. Wang dealt with the appreciable effects of space charge on large-signal theory, while A. H. W. Beck extended space-charge wave theory to the case of



An experimental S-band travelling-wave tube in the exhibition

annular beams. An elegant approach to the problems of small-amplitude disturbances in beams, by P. A. Sturrock, using a new variational principle, was challenged by B. Meltzer, who had found that the extent of applicability was limited. R. H. C. Newton, whose analysis of propagation along electron beams indicated



A large working exhibit—the ammonia maser: a new molecular clock

new magnetic modes of oscillation, must have been gratified to have his ideas confirmed by M. Chodorow, who, in the discussion, claimed to have observed such oscillations.

Some of the highlights of the week occurred in sessions 11, 12 and 13, which covered several new methods of amplification and generation. In one class were the amplifiers using 'fast wave' or Doppler effect, which were typified by the papers of R. B. R-Shersby-Harvie and A. Karp. Such mechanisms can have the advantage of not requiring a slow-wave structure for interaction, and it is thus to this type of device that we may look for higher powers at millimetre wavelengths. There were several contributions on parametric amplifiers, a name that many people would like to see changed to variable-reactance amplifiers. In these, energy is extracted from an r.f. 'pumping' source, usually of higher frequency, whose function is to cause the reactance of a circuit element to change. Contributions by G. Wade and H. Heffner and by K. K. N. Chang and S. Bloom indicated that a pumping source at a lower frequency than the signal to be amplified could be used if extra passive circuit-elements were introduced. The latter contribution was read by W. R. Beam, who indicated in no uncertain terms his distaste for a device which did not employ an electron stream. He may have found consolation in the contribution read by C. F. Quate on a parametric amplifier employing electron streams, though A. Uhlir gave results on a junction diode as a convertor for microwave frequencies which must make one wonder whether electron streams have not had their day for low-power work.

The Maser

The third class of new device was the maser, which was discussed in three papers. In this device, amplification is obtained by extracting the energy from electrons in molecules which are stimulated to change their energy state by the signal to be amplified. Once again an h.f. pumping source is needed to excite electrons from lower to higher energy levels. A most interesting variant of this device, aiming at wider bandwidths, was described in a contribution read by A. E. Siegman. In this a ruby rod is employed in a helix, and operation is on the travelling-wave principle.

Both the maser and the parametric amplifier are capable of yielding a very low noise figure provided that they are operated at low temperatures. A possible problem with the parametric amplifier is that the amplified signal may be modulated by fluctuation of the pumping source, and this effect may well restrict some uses.

Session 14, on slow wave structures and resonators, started off at a high power level. A. F. Pearce described work done in America using cavities coupled with 48 loops apiece, and J. Arnaud also had some new structures to report when he described work done in France. Great interest was demonstrated in multiple-ladder circuits, and in the discussion C. K. Birdsall had so many different configurations to report on that the projectionist could not change slides fast enough. It was a disappointment to many that not all were shown. The helix, despite competition, managed to hold its own with the last four papers, the main interest being in methods of coupling.

Puzzling the Experts

The session on noise was devoted to electron-beam devices and gave the hot-cathode people the opportunity to counter the dismay caused by the performances quoted by the solid-state men. In general, low-noise performance has previously managed to keep well ahead of theory. It was therefore most interesting to hear from W. R. Beam of recent changes in design which have produced broad-band noise figures of less than 4 dB and,

at the same time, to hear of the most recent calculations of noise in low-velocity drifting streams from J. R. Pierce, whose attendance at the convention was warmly welcomed. The results of these calculations, which appeared to puzzle the many experts in the field who were present, including Dr. Pierce himself, gave a new impetus to low-noise theory by predicting a minimum noise figure lower than has yet been attained. Modulation noise is also being considered more seriously as valves are being put to more exacting uses and, from the contribution by N. W. W. Smith, seems to be limiting the possible uses of O-type backward-wave oscillators.

In session 16, on velocity-modulation valves, the Chairman had obviously noted that, earlier in the week, there had been a tendency for the read papers to evoke the discussion, the supporting unread papers being rather neglected. He therefore took the refreshing decision that all papers and contributions, which in this case were on high-power valves, should be read. The majority dealt with valve developments on various frequencies with pulse-output powers up to 5 MW. The desirability of going to an annular beam to increase power output and bandwidth was shown by W. L. Beaver, although P. G. R. King demonstrated that wider bandwidths could also be obtained by altering the definition of bandwidth. A. L. Cullen and I. M. Stephenson returned to fundamentals with an investigation of velocity modulation at the relatively low frequency of 300 Mc/s. Their clear demonstration of the superiority of the space-charge wave theory in explaining results went far towards confounding those fundamentalists who had been advocating a return to Webster's kinetic theory of bunching.

Informal Interlude

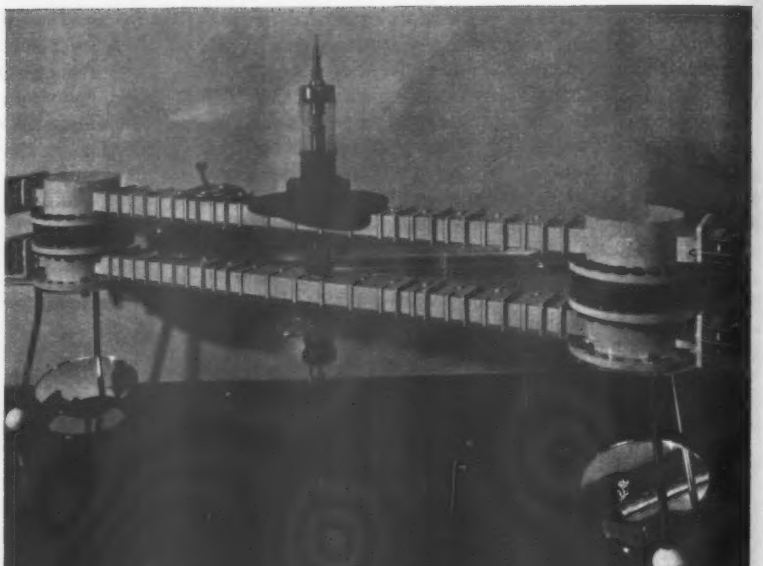
A brief and enjoyable respite from the week's activity was given on Thursday evening, when 250 delegates and their ladies met together for the informal dinner held at the Connaught Rooms. After the loyal toast, the President gave the toast of the visitors and enlivened the assembly with descriptions of recent experiences as a visitor and guest during his world tour. Replying for the visitors, Mr. Donald Fink, President of the Institute of Radio Engineers, and particularly welcome as an old friend of The Institution, enlarged on the rapid advances made in all fields of activity of both his own Institute and of the Radio and Telecommunication Section, and as an indication of this coined another information unit—the 'tup'. This was the amount of information which could be transmitted across the Atlantic for twopence, and turned out to be of surprising practical utility. Mr. Fink emphasized the significance of the presence of so many representatives from oversea and looked forward to the time when international restrictions would be only those dictated by time and distance.

The consideration of velocity-modulation valves was continued on Friday and included a description by P. A. Lindsay of experimental work on units of the highest-power microwave generator ever proposed. From his figures it would appear possible to obtain pulse powers in excess of 1000 MW over a broad band of frequencies. A novel high-power c.w. oscillator, which should have good frequency stability, was described by J. R. Pickin. A number of papers dealt with various aspects of low-power reflex klystrons, and D. J. Wootton showed that even these can be made in a high-power form by using annular electrodes.

Delegates and guests at the Convention Dinner in London on the evening of the 22nd May

Back to the Diode

In session 17, which dealt with measurement, the field covered was quite wide, ranging from the use of mechanical and electron-beam probes for the determination of field patterns on slow-wave structures to the mechanical scanning of an electron beam to find the distribution of current density. Even the thermionic diode—the forerunner of all valve development—appeared in this session. In its coaxial form, as explained by R. Redstone, it makes an efficient detector of high-power pulses, while R. B. Dyott indicated to the designer that in its use as a high-level detector of noise it can increase the sensitivity of signal/noise measurement by several decibels as compared with a good crystal mixer.



Another exhibit—an experimental periodically-loaded travelling-wave klystron

Sessions 18 and 20 dealt with electron optics. J. E. Rowe expounded his 'solid state' electrolytic tank, which had the advantage of d.c. instrumentation and could be made from cheap materials. M. R. Barber remarked that tap water is cheap, and described how refinements had been made to a conventional tank to give an accuracy of 1 part in 1000.

Gun Design

A number of papers and contributions gave methods of calculating electron trajectories and gun performances. O. Heil showed how careful gun design can make magnetic focusing in klystrons unnecessary; and contributions by W. E. Waters and H. A. C. Hogg described electrostatic methods for focusing the longer beams required for travelling-wave tubes and backward-wave oscillators, without using magnetic fields. P. A. Sturrock read a contribution by P. T. Kirstein and G. S. Kino on the use of the action function in space-charge flow problems. New types of flow are being discovered with this method.

The President took the unusual course of presenting his closing remarks at the beginning of one final session and at the end of the other. This procedure was, as Mr. Goldup pointed out, necessitated by the impossibility of his being at both of the parallel sessions at the same time. He wished the visitors *bon voyage* and voiced the opinion of all when he said that he had found the convention most stimulating and enjoyable. W. H. A.

FIRST REACTORS FOR ALDERMASTON

HORACE, a zero-energy reactor, is now operating at the Atomic Weapons Research Establishment at Aldermaston and is primarily intended for investigations into the nuclear characteristics of a light-water research reactor. It consists in an arrangement of enriched reactor fuel in ordinary water and will be used to study different types of reactor-core arrangements and the use of 'reflecting' materials.

Tests with Horace will also provide data relating to the control and safety of this type of reactor and should considerably shorten the time taken for full commissioning of a second, similar, reactor. This second reactor, known as Herald, should be completed this autumn. It also will have ordinary water as a moderator and coolant and will operate at power levels up to 5 MW. It will be used for research with neutrons and for the production of special isotopes.

There are now 35 reactors in operation or under construction in the United Kingdom for research, testing and power production.

BOILING-WATER REACTOR

THE 10 MW Halden experimental boiling-water reactor situated 120 km south of Oslo is the only boiling-water reactor in Europe and the first heavy-water boiling reactor in the world. As a result of studies undertaken within the O.E.E.C. European Nuclear Energy Agency, representatives of a number of European countries and Euratom recently concluded an agreement for its joint operation. A joint programme of research over a 3-year period beginning on the 1st July 1958 has been arranged, subject to funds being made available by the appropriate authorities: a budget of the order of four million dollars is envisaged.

An International Committee will approve the joint programme, and a Technical Group will supervise its execution. The Norwegian Institute for Atomic Energy will carry out the programme with staff recruited from the participants.

Representatives of the U.S. Government took part in the preliminary discussions and have offered American collaboration, with specialists and the exchange of information.

A REVIEW OF THE PROCEEDINGS, PARTS A AND B

Short Cuts with Digital Computers

A short review of a Measurement and Control Section paper (No. 2693) entitled 'Short-Cut Multiplication and Division in Automatic Binary Digital Computers, with special reference to a New Multiplication Process', by M. Lehman, B.Sc., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings. Dr. Lehman was formerly with Ferranti Ltd. and is now with the Israeli Ministry of Defence.

FAST AS PRESENT-DAY DIGITAL COMPUTERS ARE, THEY still do not meet the requirements of many present and proposed applications. Pulse-repetition rates of from 1 to 3 million pulses per second are in common use both in industrially produced and in experimental machines now under development. Any further worth-while increase in these repetition rates, with its related decrease in pulse width and increase in machine speed, requires more complex and 'faster' circuits, with all that this implies in assembly techniques, systems reliability and cost. Hence it is generally agreed that significant increases in computer speeds through the use of 'faster' circuits are not likely to be attained until such time as new circuit techniques and components become available. The requirement of the latter is that they permit speed-up of one or two orders without any decrease in reliability or increase in cost as compared with those of present large-scale scientific installations.

Digital-computer research and design activity have therefore during the past few years been increasingly directed to the field of logical design. Machines are, as a result, larger and logically more complex devices, though the individual circuits remain relatively simple and cheap.

The most important innovation has been that more and more portions of the machine are permitted to operate autonomously under only supervisory control of the main control circuits, so that most of the circuits in the machine are active most of the time. Order codes may also be redesigned to make them more efficient and to permit more effective and continuous use of all the machine components. Finally, thought may be given to the ways in which the individual units are to be controlled and the individual orders fabricated and executed by the machine, and it is this aspect of the over-all problem which is discussed in the paper.

Anyone who has ever used a mechanical calculating machine not containing automatic multiplication will be familiar with short-cut multiplication and division processes. If, for example, multiplication by 1981 is required, the straightforward mechanical multiplication process follows the setting-up of the multiplicand on the keyboard with, say, one turn, eight turns, nine turns and one turn, respectively, of the adder handle in such a direction (anti-clockwise, say) as to add the contents of the keyboard into the accumulator, the latter being shifted one place to the right after each set of turns. Hence the process appears to require 19 turns of the handle and three shifts. This total may be reduced considerably by a number of different methods. For example, since $1981 = 2000 - 19$, the same product could be built up by the process:

nine clockwise turns
one right shift
one clockwise turn
two right shifts
two anti-clockwise turns.

The clockwise turns subtract the contents of the keyboard from the accumulator, and the net result is to set up the product in the accumulator with a total of only 12 turns. However, even this may be improved since the multiplier may also be written as $1981 = 2000 - 20 + 1$, requiring a total of only five turns with the same shifting pattern as before.

The introduction of short-cut techniques thus greatly speeds up decimal-multiplication processes, and it is natural to ask whether an analogous process may not also be used in an automatic binary multiplier, in which each shift of the accumulator is preceded by at most one addition when the 'current' multiplier bit μ_t is (in a positive multiplier) a '1'. The short-cut process would be based on the simple identity:

$$\sum_{t=r}^{s} 2^t = 2^{s+1} - 2^r \quad . \quad . \quad . \quad . \quad . \quad (1)$$

so that, for example, multiplication by 15, which in a straightforward multiplier requires four additions, could be replaced by one subtraction and one addition.

Identity (1) shows in fact that binary short-cutting always reduces $(s - t + 1)$ operations to just two. However, a very simple calculation shows that, if short-cutting is based only on this principle, for an n-bit number an average of $\frac{1}{2}(n + 1)$ addition and subtraction operations are required, the standard process requiring only $\frac{1}{2}n$.

It is easy to see that this result is, in part at least, due to the possible occurrence of 'isolated' bits where $s = t$, i.e. a sequence such as ... 0100 ... In this case:

$$s - t + 1 = 1 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

On the other hand, short-cutting requires a subtraction followed by a shift and an addition on the basis of the identity: $2 - 1 = 1$; whereas from (2) only a single addition is really required. It can be shown that similar inefficiencies happen for all occurrences of isolated bits.

Having discovered the causes of the weaknesses of binary short-cutting, it is simple to devise a multiplier system which obeys the laws of binary short-cutting (add or subtract whenever the current multiplier bit is unequal to its less significant neighbour), except when an isolated bit, appropriately defined, is encountered during the scanning of the multiplier.

The resultant multiplier for signed multiplication turns out to be little more complicated than a straightforward multiplier, being based on the symbolic equations:

$$C_t \equiv (\mu_t \neq \mu_{t-1}) \ \& \ C_{t-1} \quad . \quad . \quad . \quad . \quad (3)$$

$$S_t \equiv \mu_{t+1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In these expressions, C_t represents the need to operate in the cycle and S_t the sign of the resultant operation, an addition being required when S_t is zero and a subtraction when S_t is unity. The expression (3) also shows that operations cannot occur in successive cycles, and hence any operation may be immediately followed by two one-place shifts, or for maximum speeds a single two-place shift. Thus in every cycle it is only necessary to compare the current multiplier bit with its right-hand (less significant) neighbour, operating when these are unequal. The sign of the operation depends on the left-hand neighbour, and operations may be followed by a two-place shift. When no operation occurs a single-place shift is required.

Simple analysis shows that this multiplication process, which has been termed the modified short-cut or m.s.c. process and which may be used with all common systems of negative-number representation, reduces the average number of operations (addition or subtraction) to approximately $\frac{1}{3}n$ and may also reduce the average number of shifts required by one-third.

In the application of short-cut methods to binary dividers, unnecessary operations (for example, in a restoring divider if the subtraction will clearly 'not go') can be avoided by a comparison of one or two of the leading bits of the divider and the dividend. Similarly, in a non-restoring divider, in which the dividend is added to or subtracted from a partial remainder, depending on whether the latter is negative or positive, it is possible to give a third alternative, namely that neither operation is performed. The problem of recording these three alternatives in a binary machine can be solved in a relatively simple manner, and the paper briefly discusses some of these problems. 681.142

SYNOPSES OF PAPERS

The following are synopses of papers published in the *Proceedings* which have not been read at an Institution meeting and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints of them will be available shortly (see p. 511).

Industrial Electrical Measuring Instruments

A synopsis of a review of progress (Paper No. 2682) with the above title, by F. R. Axworthy, Member. The review is published this month in Part B of the Proceedings. The author is with Everett, Edgcumbe and Co. Ltd.

PROGRESS IN THE DESIGN OF INDUSTRIAL ELECTRICAL measuring instruments during the last 10 years has been steady and continuous rather than spectacular. Possibly the major factor affecting instrument design has been the availability of new or improved materials. For example, the improvement in permanent magnets has led to the introduction of more efficient magnetic circuits for moving-coil instruments. These new magnetic circuits are self-shielding and have relatively low magnetic leakages. A number of instruments are now made with their coil embracing the magnet, a design which is only practicable with modern high-energy magnets. Production of moving-coil instruments has been simplified by the use of 'composite' magnets which are partly hard and partly soft iron. Thermoplastic materials may be used either for their excellent insulating properties or as an aid to more rapid production. Where extremes of temperature are possible, silicone materials are used. Thus, a silicone-modified enamel covering for winding wires can be used at temperatures up to 150°C, and silicone-rubber sealing rings and gaskets are used on hermetically sealed instruments designed for operation in temperatures varying from −40° to +70°C and in atmospheres up to 95% relative humidity.

Printed circuits are now in use for instruments. A new multi-range test-set has printed series and shunt resistors, while an insulation tester, having a transistorized voltage convertor, uses printed wiring.

Long-scale instruments are becoming more popular, and new high-torque moving-coil, moving-iron, dynamometer and induction instruments have been developed in which the scale arc subtends an angle of 240° or more. Quite recently, portable long-scale instruments have appeared.

Much thought is being directed towards presenting the results of measurement in digital form, both for direct

display as a number or as a binary code suitable for feeding into calculating machines. Various schemes are being studied; probably the use of patterned discs in conjunction with relay circuits to convert angular or linear motion into either binary or decimal codes has reached the most advanced stage of development. These techniques, which will be of major importance in the application of digital computers to automatic process control, are not likely to reduce the need for the more humble pointer instrument. 621.317.2

Scientific Electrical Measuring Instruments

A synopsis of a review of progress (Paper No. 2695) with the above title, by F. C. Widdis, B.Sc.(Eng.), Associate Member. The review is published this month in Part B of the Proceedings. The author is at the Northampton College of Advanced Technology, London.

THE LAST REVIEW OF PROGRESS IN THE DESIGN OF SCIENTIFIC measuring instruments was published in 1946. The upsurge in scientific and technological progress since then has necessitated considerable development in measuring techniques. The rate of progress in any branch of science is determined to a considerable extent by the ability to measure the phenomena under investigation. New instruments have been developed for new applications, and much effort has been devoted to improvements in existing measuring apparatus to cope with the continual demands for improved performance and reliability. In many applications a degree of accuracy is now expected from commercial instruments that has hitherto been achieved only by the most refined laboratory techniques.

As it is not possible in the course of a single paper to deal with the whole field of scientific measuring instruments, the review is restricted to a consideration of those devices which are primarily of interest to the electrical engineer, or which utilize electrical measuring techniques.

The most important developments in the period that has elapsed since the last review have probably been in connection with nuclear phenomena and their applications, semi-conductor devices and electronic instruments.

There will undoubtedly be a further expansion in the field of electronic instrumentation, and efforts will be directed towards improvement in the general reliability of electronic devices.

The multiplicity of instruments now used in experimental work introduces a serious space problem, and it is desirable that efforts should be made to effect a substantial reduction in instrument size without sacrifice of performance. The transistor may enable this to be done in the case of electronic instruments.

Automatic measuring and indicating instruments are common in industrial process work, and in some cases an accuracy of the order of 0·1% is attainable. Some recent industrial instruments display the measured quantity in digital form, which can give a very high reading accuracy. It is probable that this technique may be generally extended to laboratory instruments; self-balancing a.c. bridges have already been constructed for routine network analysis. This may be of importance where the readings are made by semi-literate operatives in under-developed countries. 621.372.2

Location of Sheath Faults in Pressurized Telephone Cables

A synopsis of a Radio and Telecommunication Section paper (No. 2710) entitled 'The Factors Influencing the Use of Pneumatic Methods for the Location of Sheath Faults in Pressurized Telephone Cables', by E. J. Hooker, M.A., Ph.D.(Eng.). The paper is published this month in Part B of the Proceedings. The author is with Southern United Telephone Cables Ltd.

AN EXPRESSION, BASED ON THE CLASSICAL POISEUILLE equation for gas flow through capillary tubes, has been obtained to describe the passage of gas through non-coaxial telephone cables under steady-state conditions; and, for cables in this category, the factor governing the flow has been shown to depend upon the number, gauge and arrangement of the conductors. An approximation of the pressure gradient associated with a small rate of gas flow has been derived from this expression, and consideration has been given to the degree to which this limits the successful location of sheath faults by methods involving the direct establishment of the pressure gradient, the installation of pressure-sensitive contactors, rate-of-flow measurements and the use of flow-direction indicators. 621.315.23 : 621.317.333.4

Cable Characteristics Measured through Loss-Free Junction

A synopsis of a Radio and Telecommunication Section paper (No. 2689) entitled 'Measurement of Impedance and Attenuation of a Cable through an Arbitrary Loss-Free Junction', by J. Allison, B.Sc.(Eng.), Ph.D., Graduate, and F. A. Benson, D.Eng., Ph.D., Associate Member. The paper is published this month in Part B of the Proceedings. The authors are in the Department of Electrical Engineering, University of Sheffield.

THE PAPER CONSIDERS THE PROBLEM OF FINDING THE impedance and attenuation of a transmission line when measured through an arbitrary loss-free junction. Several possibilities for the exact determination of impedance in such a case are mentioned, and the results of tests carried out to determine the usefulness and accuracy of certain methods are presented. Some information is also given on the experimental accuracy of the well known circle-diagram technique for determining transmission-line characteristics. 621.317.34 : 621.372.2

Position Control of Massive Objects

A COMPREHENSIVE treatment of the position control of massive objects, by a team of experts led by Prof. A. Tustin, is being published in November in the form of a paper, which, in effect, is a short textbook. Together with a supporting paper on dimensional relationships in control systems, by Prof. Tustin, the main paper will appear as a Supplement (No. 1) to Part C of the *Proceedings*.

The Supplement will run to some 64 pages and will be bound in semi-stiff covers. The prices (post free) are 8s. 6d. to members of The Institution and 15s. to non-members. Application for copies should be made on the order form enclosed with this issue. The edition is limited, and there will be no reprints of the papers. Synopses are given below.

The Design of Systems for Automatic Control of the Position of Massive Objects

PROF. A. TUSTIN, M.SC., J. T. ALLANSON, M.SC., J. M. LAYTON, B.A., B.SC., *and* R. J. JAKEWAYS, PH.D.

THE AUTHORS consider the particular class of automatic feedback control systems in which the purpose is to move a massive body in agreement with the variations of an input quantity, usually the angular displacement of a shaft. The power required for the movement of the load being far too great to be obtained direct from a thermionic amplifier, additional amplification is provided, for example, by magnetic or rotary amplifiers.

The design of such systems is constrained by the need for limitation of torque and speed and by many other considerations not taken into account in discussions of control systems in general. It is shown how these constraints may be regarded as restrictions on the log-gain/log-frequency diagram.

The time-constants associated with the power-amplifying elements depend on the power and dominate the design. The possibility is therefore considered of meeting the specification by suitable choice and arrangement of the non-thermionic amplifier stages.

By introducing the relationship between power amplification and the associated time-constants, it has been possible to express the conditions for adequate damping in terms of power amplification and accuracy, together with simple functions which express the contribution made towards meeting the requirements in using up the limited amount of phase lag allowable. These 'phase-utilization functions', which are characteristic for the various classes of machine amplifier that may be used, may be calculated once and for all for given classes of dynamically similar elements.

The following is a brief review of the paper's six sections.

1. THE CONFLICTING REQUIREMENTS FOR A POSITION-CONTROL SYSTEM EXPRESSED AS CONSTRAINTS ON THE LOG-GAIN/LOG-FREQUENCY DIAGRAM FOR THE CONTROL LOOP

This section presents the specification of the system and considers its implications in terms of the required log-gain/log-frequency characteristics.

2. THE DESIGN OF THE MOTOR AND THE GENERATOR WHICH FEEDS IT, AND A DEFINITION OF A 'STEADY-STATE POWER AMPLIFICATION'

The design of the motor and the generator which feeds it must ensure that both are adequate to give the requisite movements to the load, these movements being defined statistically. These considerations lead to a definition of the power amplification required and provide both a basis for ensuring that all elements have adequate ratings and a prior estimate of the supplementary small angle of lag or lead associated with the motor armature circuit.

3. SELECTION OF ELEMENTS TO PROVIDE REQUIRED POWER AMPLIFICATION, SYSTEM GAIN FACTOR, PHASE-MARGIN AND RATING

The selection of machine-amplifier elements to provide the power amplification is discussed, and the concept of phase utilization is developed, making use of the fact that the time-constants and power amplification are related.

4. DESIGN OF MODIFYING NETWORKS

The section shows how the modifying networks for insertion in the thermionic stages may be selected when it has been ensured, by the principles discussed in sections 1 and 3, that the requirements can be met.

5. MODIFICATION OF THE TRANSFER-FUNCTIONS OF MACHINE AMPLIFIERS BY FEEDBACK AND OTHER MEANS

In an examination of the use of feedback on machines as a contribution to meeting the requirements, it is shown that the apparent benefits of some types of feedback may be offset by reduction in power amplification. This leads to a discussion of feedback by means such as transformers, which introduce a derivative term.

6. IMPLICATIONS FOR CONSTRUCTION

This section gives a brief indication of how a physical construction may be achieved to conform with the time-constants found to be desirable, discusses the general nature of the limitations to the attainable performance, and suggests some possibilities for improvement.

Similarity and Dimensional Relationships in Control Systems

PROF. A. TUSTIN, M.SC.

THE essential theorems of dimensional analysis are reviewed and related to the familiar process of normalizing or 'non-dimensionizing', by which the results of calculation or observation of relationships between varying quantities may be expressed so as to be applicable to many possible observations.

In recording or cataloguing the behaviour of systems of given kinds having various combinations of values of parameters, it is desirable to express the behaviour in terms of the fewest possible composite parameters. It is shown that, for transfer functions, this is achieved by the usual process of normalizing applied to the transfer function when expressed in the form of a ratio of polynomials in p. In systems with feedback, this number of parameters may be smaller than the number of the ratios of independent time-constants of the equations. This implies that systems with feedback may have dynamically similar behaviour, even though their basic time-constants are in different ratios.

Consideration is given to systems involving non-linear relationship. In such cases the choice of the products, having dimension zero, in terms of which results may most effectively be recorded is particularly important and may be less obvious. A procedure is outlined, using the concepts of sets of affine curves and representative values, by which the appropriate composite variables may be discovered.

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

GEORGE HERBERT FLETCHER

George Herbert Fletcher, O.B.E., who died on the 20th December 1957, at his home at Appleby, Westmorland, was born at Preston on the 9th August 1886. He was educated at Moor Park Academy, Preston, and received his technical education part-time at the Victoria Technical College while serving an apprenticeship at Preston with Dick, Kerr and Co., where later he was in charge of the testing of a.c. machines.

He moved to Manchester in 1914 to join the British Westinghouse Electrical and Manufacturing Co. as a design engineer on a.c. machines, and for a period was responsible for induction-motor design.

In 1919 he took charge of traction-motor design. The manufacture of traction motors was transferred to Sheffield in 1920, and the design staff followed in 1922, when Mr. Fletcher became Chief Engineer of the newly formed Traction Motor Department. In 1930 he was appointed Chief Engineer and Manager of the Sheffield Works of Metropolitan-Vickers, and from then he became increasingly concerned with management problems, although still retaining his keen interest in technical matters. In 1939, with his characteristic energy, he organized the rapid change-over from traction products to work for the Services. In 1948 he was appointed a Director of the Metropolitan-Vickers Electrical Export Co. and in 1949 General Manager of the Sheffield Works, a post he held until his retirement in 1951, after which he acted as a consultant for three years. From 1954 he became a consultant on traction matters to the General Electric Co., Witton. At the time of his death he was engaged in delivering the 1957–58 Faraday Lecture, 'The Electrification of the British Railways'.

During the course of his career he was responsible for a number of papers and lectures before various bodies. For many years he took a prominent part in the work of the B.S.I. on traction motors and in the related work of the I.E.C. As a result of his I.E.C. work and his responsibility for the development of the motors for many important electrification schemes, he acquired an international reputation as an expert on traction motors.

During his period on the management side he played a considerable part in local industrial affairs and was a member of many committees, often serving as chairman. He had a particularly strong interest in educational matters and served on several committees. He was for a period a member of the Board of the Faculty of Engineering of Sheffield University. For his services to industry he was appointed an Officer of the Order of the British Empire in 1952.

Mr. Fletcher was chiefly noted for his inventiveness, energy and enthusiasm, which continued during his retirement right up to the time of his death. He is survived by his widow and a son.

Mr. Fletcher joined The Institution as an Associate Member in 1919 and was elected a Member in 1930. He was awarded an Institution Premium in 1939 for a joint paper with Prof. A. Tustin entitled 'The Metadyne, and its Applications to Electric Traction'. He served on the Sheffield Sub-Centre Committee from 1926 to 1944, being Chairman in 1943–44, and on the North Midland Centre Committee in 1943–44. He was a Life Member of the American Institute of Electrical Engineers and a Member of The Institution of Mechanical Engineers. H. N.

HARRY HEWLETT RICHARD GREEN

Harry Hewlett Richard Green, who was born on the 19th October 1877, died on the 9th May 1958. He was educated at the City of London School and Finsbury Technical College. In 1895 he became apprenticed to the London and South Western Railway Co. at their Nine Elms Engineering Works.

Subsequently, for some years, he was engaged on the design of mechanical and electrical machinery and equipment and on the conversion from steam to electric drive in large steel works and at Guinness's brewery in Dublin. In 1904 he joined Vickers Sons and Maxim, Barrow, and worked particularly on the design of electrical control machinery and apparatus for large gun mountings for British, Japanese and Russian ships.

In 1906 he was appointed to the Electrical Engineering Department at the Admiralty, where for many years he was engaged on electrical-design work for all classes of H.M. ships then under design and construction. During the First World War, he served afloat and gained valuable experience in the use of the equipment under war-action conditions. He received a special award for an invention in circuit-breaker control used by the Royal Navy. Green was a competent and progressive designer of ships' electrical equipment and as such was always a forceful and sincere advocate of that which he thought would produce the most efficient and reliable results, particularly in active service; thus occasionally he appeared somewhat obstinate, but subsequent practical experience of the equipment brought him in fact many additional friends. Normally he was of a retiring nature. He was promoted to the position of Admiralty Electrical Engineer in charge of the North-Western Section and subsequently as Superintending Electrical Engineer at the Admiralty, London, to supervise the electrical work in capital ships, cruisers and destroyers, a post which he held until retirement in 1937.

Green was keenly interested in problems concerning wireless and its development, and in retirement continued this study; he also found much relaxation and enjoyment in his garden. He leaves a widow and two daughters.

Mr. Green joined The Institution as an Associate Member in 1903 and was elected a Member in 1919. W. McC.

LIONEL LAMB

Major Lionel Lamb, T.D., after about a year's illness, was admitted to Westminster Hospital, where he died on the 10th May 1958. He was born on the 11th September 1885 and was educated at the Grocers Company School, Hackney, and East London College, where he received his training as an electrical engineer under Prof. MacGregor-Morris.

In September 1904 he joined the staff of the Electrical Engineering and Physics Department of the Northampton Institute, London. The following year he developed an interest in X-ray research which was maintained throughout his life. He was a pioneer in this field, being associated with Dr. Butcher in designing equipment for Newton and Wright Ltd. This in no way interfered with his educational activities, and he remained as a Lecturer and Demonstrator at the Northampton Institute till 1911, when he resigned to devote the whole of his time to X-ray development with Newton and Wright. To gain wider experience he joined the staff of British Insulated Cables Ltd. in 1913.

In 1914, at the outbreak of the First World War, he joined the Royal Engineers (Signals Branch) Territorial Unit. He served in France, being twice mentioned in despatches, and reached the rank of Major. After the war he maintained his contact with the unit and at the outbreak of the Second World War was transferred to the Royal Artillery, serving first in the Plymouth Operations Room and later in the Gloucester Technical Training Group under Brig. F. T. Chapman.

From 1919 to 1925 he was Assistant Electrical Engineer for the India Office Store Depot. He then returned to teaching at the Hackney Technical Institute, later being transferred to Leyton Technical College. When the two technical colleges were opened

in Essex, Major Lamb was first appointed to the South-West Technical College, Walthamstow, as Senior Lecturer in Electrical Engineering from 1938 to 1943, and then to the South-East Technical College, Dagenham, where he remained until his retirement in 1950. From that time onwards he did part-time teaching at various colleges, including Faraday House.

His life, whether in education, in the Army, or in industry, was a life of devoted service. He will always be remembered with thankfulness and kindly affection by his students for his patience, for the care that he always took with individual students, and for his enthusiasm. Those who worked with him at any time hold him in high esteem and value his loyalty and friendship. His interests were wide and concerned with public well-being. He was a member of many hospital committees and at one time a member of Hackney Borough Council. He is survived by his widow and a daughter.

Major Lamb joined The Institution as a Student in 1904 and was elected Associate Member in 1911 and Member in 1942. L. W. P.

ARTHUR GROTJAN MARSHALL

Arthur Grotjan Marshall was born on the 2nd August 1875 and died of pneumonia on the 19th April 1958, after about 18 months of generally failing health. His son is Arthur Calder-Marshall, the well-known novelist, journalist and broadcaster.

Marshall's early education was at Colet Court and then at St. Paul's School. Deterred by his family from his desire to become an artist and by financial considerations from his second choice of the medical profession, he finally settled on electrical engineering and went from St. Paul's to the Regent Street Polytechnic.

In 1895 he joined the House to House Electric Supply Co., Fulham. To augment his low income at that time, he contributed to a question and answer column in an electrical periodical. To keep it going, he provided not only the answers but also the majority of the questions and received payment for both.

In 1899 he left Fulham to join the staff of R. P. Wilson, the consulting engineer, and in 1905 set up his own consulting-engineering business in Victoria Street. Here began a series of contracts which satisfied his latent ambition for oversea travel, taking him to the Far East, to Jamaica and to South America.

In 1913, when in Vladivostok, Marshall discussed with the British Consul there the possibility of opening up Siberia as a market for British electrical products. He formed the co-operative selling organization known as the British Engineering Company of Siberia (B.E.C.O.S.), with himself as Managing Director. The outbreak of the First World War changed the commercial activities of the company so that it became concerned chiefly with the export of British war materials to Russia and the building of cars and trucks in that country, under licence from Crossley Bros. With the Revolution the factory was expropriated, together with all the firm's assets in Russia, and Marshall returned home in 1918, having lost a fortune.

He believed, fervently, in the possibility of doing trade with the Bolsheviks. He was a founder member of the Russo-British Chamber of Commerce, of which he was Chairman for many years and which he represented on the Board of the London University School of Slavonic Studies. At this time he opened B.E.C.O.S. offices in the Baltic States.

Between the two wars Marshall negotiated the Lena Goldfields settlement after the Soviet Government had rejected The Hague award and the Directors of Lena Goldfields had themselves failed to secure satisfactory terms. This was a great personal triumph for him. Unfortunately, it was comparatively short-lived because, when the Soviet Union seized the Baltic States and the British Government froze their assets in this country, the Soviet Government suspended payments on the Lena agreement.

B.E.C.O.S. being deprived of its alternative trade outlet by the Second World War, Marshall formed three groups, namely heaters, fans and ancillary equipment, and the British Chipboard Manufacturers' Association, for whom he acted as adviser and liaison officer with the Board of Trade and other Government departments.

Arthur G. Marshall was an intensely active man and an incurable optimist, and, though sometimes described as 'a man of iron', he was tireless in his efforts to help anyone who appealed to him for assistance. Puffing away at the short-stemmed pipe which was almost part of him, he would listen, attentively and patiently, to anyone who chose to consult him, his keen eye revealing an intelligent and helpful interest usually far beyond the expectations of his visitors. He was an inveterate and meticulous collector of a wide range of objects from snails to dolls; a carpenter, wood-carver and model-maker of more than average ability; and an inventor never happier than when thinking out a technical problem. By his passing the world has lost an energetic, determined and colourful personality who will be greatly missed by a very wide circle of friends and acquaintances.

Mr. Marshall was elected a Member of The Institution in 1909 and was an Associate Member of The Institution of Mechanical Engineers. He was a member of the Society of Sussex Downsmen and Chairman of the Worthing branch of the Overseas League.

F. R.

SIDNEY BERTRAM SMITH

Sidney Bertram Smith, who was born in Fulborn, Cambridgeshire, on the 25th August 1891, died in Chelmsford on the 21st April 1958. He attended Goldsmiths' College, London, from which he joined Marconi's Wireless Telegraph Co. in 1912.

During the 1914–18 War, as a Lieutenant in the R.N.V.R., he carried out work on radio direction-finding in Eygpt and South Africa. In 1919 he rejoined the Marconi Co. and, in the Research Department, continued with his direction-finding work as a prime interest. He was largely responsible for the commercialization of the Adcock system, whereby spectacular advances were made in the avoidance of errors due to polarization effects.

In the 1920's Mr. Smith took an active part in the setting-up of high-speed radio-telegraph services between Chelmsford and European capitals and somewhat similar services at Geneva for the League of Nations. He was thereafter engaged, with the late G. M. Wright, in developing some of the earliest high-quality photo-telegraphy equipment to be used on long-distance radio channels. He was also responsible for the development of commercial telegraph receivers, and the support he gave to the design and use of signal generators helped to define the performance of receivers on a quantitative basis. In connection with his various activities, Mr. Smith's name appeared on more than 30 patent applications. During the 1939–45 War he carried out extensive direction-finding research on behalf of the Admiralty and participated actively in the work of the Inter-Services Ionospheric Bureau. He served on many international committees and conferences, notably those of the C.C.I.R. for the International Telecommunication Union. He was appointed Chief of the Patent Department of the Marconi Co. in 1950.

After his retirement, in 1956, he devoted much of his time to a garden which he loved. He is survived by his widow, Grace, his daughter, Pamela, and his son, Phillip.

Mr. Smith joined The Institution as a Student in 1911 and was elected an Associate Member in 1917 and a Member in 1946. He served on the Wireless Section Committee from 1937 to 1939 and from 1944 to 1947. N. L.

HERBERT W. WATTS

Lt.-Col. Herbert W. Watts, who died at Epsom, Surrey, on the 11th May 1958, was born on the 9th March 1876. He was educated at Elmshurst School, Surbiton, and received his technical education at Finsbury Technical College, London, serving an apprenticeship with James Swinburne and Co.

There followed a long and varied experience with the electrical industry, until his appointment in 1899 as Chief Engineer to the Alderley Edge and Wilmslow Electric Supply Co. In 1901 he joined the Urban Electric Supply Co., as Chief Engineer of the Walton-on-Thames, Weybridge and Hersham undertaking. He also held appointments at Ayr, Kingston-on-Thames, Chatham and Hammersmith.

Col. Watts was a keen member of the Territorial Army and during the 1914–18 War served with the Royal Engineers both in India and this country. At the end of the war he was appointed Industrial Engineer to the Director of Ordnance Factories to the Government of Madras. On returning to this country in 1922 he served with the Yorkshire Electric Power Co., Hackney Electricity Department and the Electrical Development Association.

As Borough Electrical Engineer at Epsom, from 1925 until his retirement in 1941, Col. Watts introduced and carried out a number of development schemes, which considerably enhanced the efficiency of the undertaking. He was an active member of the Incorporated Municipal Electrical Association and served on a number of the Electrical Development Association committees.

Outside his profession his main interests were boats and motor cars. He loved to 'mess about with boats' and in his earlier days coached a number of Thames crews. He was a popular figure at most of the regattas, including Henley. As one would expect, he was a keen disciplinarian, but he was nevertheless a kindly man and generous to those in need. He leaves a widow and one son.

He joined The Institution as an Associate in 1898 and was elected an Associate Member in 1902 and a Member in 1921.

W. B. H.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings, and monographs, are first published individually and are republished later in the Proceedings; as soon as these separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition, reprints of papers read at meetings, including the discussions thereon, and of papers not read at meetings, become available, price 2s., within two months of their appearance in the Proceedings.

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(It is to be noted that these arrangements slightly modify the previous procedure, as to price and the availability of papers without charge.)

PAPER

The Application of Transistors to Line Communication Equipment *Paper* 2722 R: *Part B*

H. T. PRIOR, B.SC., D. J. R. CHAPMAN, B.SC., *and* A. A. M. WHITEHEAD, B.SC.

THE paper discusses the ways in which the use of transistors affects the design of communication transmission equipment for land lines. Transistors have many advantages over valves, but in practical equipment it has been necessary to wait for transistors of sufficient reliability.

The first step is to design equipment which is compatible with existing valve equipment. It is practicable, with transistors, to be much more free in the use of active circuits, and this makes possible new approaches to the design problems.

A more important aspect is that with transistors new types of system become possible. Battery operation of relatively complex equipment at unattended stations is feasible. Very small low-power repeaters needing no buildings alter the balance relating to repeater cost in the direction of cheaper cables with more frequent repeaters. Freedom in the employment of active elements facilitates the application of the digital circuits needed for pulse systems.

The prolific development of semiconductors makes it difficult to steer a reasonable course between making use of progress and restricting the number of types in operation. It is likely that semiconductors will be eventually the only active elements employed. *To be read on the 5th January 1959*

MONOGRAPHS

Propagation around Bends in Waveguides *Monograph* 311 R

PROF. H. E. M. BARLOW, PH.D., B.SC.(ENG.)

WHEN a waveguide supporting a given mode is bent at some point along its length, there is generally a problem in providing for the continuity of the same undisturbed field pattern throughout. The hollow metal rectangular waveguide transmitting the dominant H_{01} mode and bent in the E-plane is an exception to this, but for the most part mode conversion occurs at the bend, which can have serious consequences in multi-mode tubular waveguides or in surface waveguides.

To minimize this difficulty in the circular H_{01} waveguide, a proposal was made previously to use an inhomogeneous dielectric in association with the waveguide as a means of accelerating the wave pattern on the outside of the bend and retarding it on the inside, so as to approach much more closely the ideal conditions.

In the present paper, this idea has been extended to other forms of waveguide, and dielectrics which might find application in this way are briefly discussed.

A Topological Investigation of Network Determinants *Monograph* 312 R

P. R. BRYANT, M.A., M.SC.

POLYNOMIALS associated with network functions are investigated by simple topological methods.

The main result is contained in theorem (1) which states that the determinant of the nodal admittance matrix P of a connected RLC network without transformers is of the form:

$$\det P = \frac{\left[\begin{array}{l}\text{polynomial in } \lambda \text{ containing a constant term and} \\ \text{of degree } (2N + 2 - S_C - S_{CR} - S_L - S_{LR})\end{array}\right]}{\lambda^{N+1-S_L-S_{LR}}}$$

Here, λ is the complex frequency variable, N is the number of nodes in the network, and S_C, S_{CR}, S_L and S_{LR} are the connectivities of those sub-networks of the given network formed, respectively, of the capacitors only, the capacitors and resistors only, the inductors only and the inductors and resistors only.

This result is based on an expression for det P as the sum of tree-products, which are defined.

A dual result is obtained for the determinant of the loop-impedance matrix, and the extension to other network functions is indicated, the driving-point admittance function being taken as an example.

SOME RECENT BOOKS

G. M. ETTINGER

MAGNETIC AMPLIFIERS

METHUEN. 2ND REVISED EDITION. 1957. 102 PP. 9S. 6D.

THIS book, one of Methuen's monographs on physical subjects, now appears in a revised edition. After an introductory summary of the material, the author devotes chapters to saturable reactors, full-wave, half-wave and harmonic magnetic amplifiers, ferro-resonant circuits, and time lag and transient response. In the final two chapters, excursions are made beyond the field conventionally associated with magnetic amplifiers, and these chapters are given to saturating core elements for computers and to microwave applications of ferrites.

The author has clearly been faced with a difficult choice in the presentation of the material. He could give a unified didactic treatment of the fundamentals, or a more detailed account of quantitative design criteria, or lastly a comprehensive but necessarily shallow survey of the whole field. He has chosen the last of these alternatives, backed up by a detailed and up-to-date bibliography of nearly 140 references.

The book will therefore be most useful to the circuit designer who has to use magnetic amplifiers occasionally, and wants to find his way quickly to the right literature reference. The student will find the book a readable introduction to the subject, burdened with a minimum of mathematics; but the magnetic-circuit specialist will be disappointed by the lack of coherent quantitative design information, although the book contains a mass of detailed facts.

The relevance of the final chapters on magnetic computer elements and on microwave applications of ferrites might be queried by purists, but the author succeeds in giving a good condensed survey of the physical principles on which these applications rest. His literature references here point mainly to the pioneer publications on which the avalanche of recent papers in these fields is based.

To sum up: this is a readable book for the student and the non-specialist engineer, supported by a comprehensive bibliography.

H. E. BRIDGERS, J. H. SCAFF AND J. N. SHIVE (Editors)

TRANSISTOR TECHNOLOGY VOL. 1

VAN NOSTRAND. 1958. 661 PP. £6 11S. 6D.

THE contributions made by the Bell Telephone Laboratories to the development of the transistor have been of supreme importance. Not only did its scientists discover transistor action and predict the performance of junction transistors, but its technologists overcame many difficulties in developing methods—often elegant methods—for preparing the monocrystalline germanium and silicon so vital for transistors; and its engineers carried out much of the early analyses and characterizations of the properties of transistors needed to simplify circuit design. When therefore it announces three books on transistor technology—in its series which already includes Bode's *Network Analysis and Feedback Amplifier Design* and Shockley's *Electrons and Holes in Semiconductors*—we can expect authoritative accounts. Vol. 1 fulfils that expectation, although it is to Vols. 2 and 3 that we must look for the descriptions of silicon technology, the alloy and diffusion processes, surface effects, characterization at high frequencies, and many other important developments. Vol. 1 was largely written in 1952, so that, despite revision and some additions, it is primarily a detailed account of the first four years of the transistor.

The book is in five parts. A short first part describes the purification of germanium and the process of zone levelling. The production of monocrystals of controlled resistivity, or having *n–p–n* structures, is the main subject of the second part. The third and longest section describes the design and making of point-contact transistors and grown junction transistors—from the choice of materials, preparation of the semiconductor, etc., to the final surface treatment and encapsulation (here termed capsulation—dictionaries, please note!). The fourth part, more analytical in approach, characterizes transistor performance and describes methods of measuring the parameters of transistors. A final, very short, part introduces transistor reliability.

Although there are more than 30 contributors, the reader is hardly likely to notice any marked change of style; but he will find some subjects dealt with more than once, e.g. the four-probe method of measuring resistivity and the theory of the greater-than-unity current gain of point transistors. The formula for the well known etchant CP4 is given twice, with 30 times as much bromine on the second occasion; but mistakes seem otherwise very rare.

Engineers, as users of transistors, and transistor manufacturers will find the book of historical value; it will help newcomers, particularly, to appreciate the problems which faced the pioneers of transistors and it will undoubtedly be referred to many times in Vols. 2 and 3, which we can await, with confidence, for descriptions of the many developments since 1952.

B. K. LEDGERWOOD (Editor)

CONTROL ENGINEERING MANUAL

MCGRAW-HILL. 1957. 189 PP. £2 18S.

THIS volume consists of a collection of articles which have been published in the American journal *Control Engineering*. The material has been well chosen, and the editor has been unusually successful in the difficult task of selecting and bringing together within a single cover articles which are both compatible and not overlapping in their subject-matter.

The publication is described as 'A Guide to the Practice of Control-Systems Engineering . . .', but however interesting the individual articles may be they cannot, in the reviewer's opinion, be considered as forming a guide to design practice. This is really self-evident, and it would have been better if the title of the book had been more happily chosen.

However, if the reader is not misled by the title he will find a great deal of interesting information on control-system design over a wide field, provided that he has not previously read the articles when they were first published. Much depends on whether the reader is interested in process control or in

the electrical and servo fields as applied for example to aircraft, guided missiles and so on.

The first section on 'How to Practise Control-Systems Engineering' may well be the most useful part of the book to those interested in process control. It stresses the necessity of knowing the characteristics of the process to be controlled before making an attempt to design a control system, and it also points out that in most process-control applications the data necessary for calculating these characteristics are not yet available. Of the eight examples given to illustrate this section, about half are taken from the process-control field and are well chosen for their purpose. It might perhaps be true to say that, having read this chapter and appreciated that the hold-up in process-control-system design is due to lack of data on the processes to be controlled, the reader from the process industries need hardly proceed to the rest of the text, which, to a large extent, deals with the electrical and servo type of application and takes its examples from these fields.

The reader should note that the publication date suggests that the text is more up to date than it actually is. This is an inherent difficulty always encountered in assembling a book of this sort from individual articles and is illustrated by the deficiencies in chapter 8, 'Basic Books for your Control-Engineering Library'. This chapter remains substantially as it appeared in *Control Engineering* in late 1954 and early 1955. Naturally, it suffers from some very important omissions, and these must inevitably be paralleled by similar failings in the text of some of the other chapters, owing to the date of publication of the original articles.

On the whole, however, the information presented is representative of current practice, although recent intelligence about advances in such fields as computer control, magnetic-amplifier techniques and transistor applications would have given section 2, 'The Tools of Control Engineering', a more up-to-date appearance.

The book might form a useful addition to a library, but it is not recommended to the individual reader as being the best guide to control-system design, although the first section might well give a useful warning about the problems to be overcome before system design can be successfully applied.

H. A. McGHEE

INDUSTRIAL TELEVISION

NEWNES. 1957. 120 PP. 15S.

WHILE we are all familiar with the entertainment applications of television, there is a new and rapidly expanding field of industrial or closed-circuit television making use of the same basic techniques. In industrial television the pick-up device may be simpler and is preferably smaller, the connection with the display device is by cable, and above all, the whole equipment must be reliable, easily maintained and inexpensive.

The author is with a manufacturing organization which has pioneered the design, production and application problems of suitable equipment, and he has been able to compress into a comparatively small volume a practical account of the present state of the art.

The book is divided into two parts, the first dealing with consideration of the choice of pick-up device and its associated control equipment, and the second describing a wide variety of applications of industrial television and the way in which the equipment design is affected by the application problems.

While the author does not pretend to cover apparatus design in any detail, his outline is clear and well balanced, and this book is recommended to all those seeking solutions to problems of visual communication in the fields of research, education, industrial process development and office mechanization.

It is interesting to recall that many of the pioneering papers in this field were read at The Institution's Television Convention in 1952, and this is recognized in the author's references at the end of each chapter.

M. PHISTER, JNR.

LOGICAL DESIGN OF DIGITAL COMPUTERS

JOHN WILEY: NEW YORK. CHAPMAN AND HALL: LONDON. 1958. 408 PP. £4 4S.

R. K. RICHARDS

DIGITAL COMPUTER COMPONENTS AND CIRCUITS

VAN NOSTRAND. 1957. 511 PP. £3 4S.

THE author of the second of these books states that it is intended to be a companion book to his previous work, *Arithmetic Operations in Digital Computers*, published in 1955, which was concerned mainly with logical design. It may therefore be a little unfair to link his present work with a volume on logical design by another author. Nevertheless, these two recently published books, both by eminent authorities, are to such an extent complementary as to justify a joint review, and they are confidently recommended as companion volumes forming a treatise on modern digital-computer techniques, suitable both for students and for practising engineers. For the most part they are concerned in detail with engineering practice to date rather than with the most recent developments, and for this reason their usefulness to those engaged in the development of computers will lie mainly in providing a handy work of reference to subjects outside the specialist's particular activity. Both volumes will be of particular value to the growing number of engineers who are not specialists in the design of general-purpose computers, but who are concerned with designing digital data-processing systems for special applications.

Logical Design of Digital Computers deals mainly with the elementary principles of Boolean algebra and its application to logical design. The subject is covered extensively and thoroughly, and the book is notable for its clear explanations and well chosen examples. In particular, the example of design of a counter having an arbitrary output sequence is in itself convincing corroboration of the author's claims for the power of the method. In spite, however, of the disclaimer in the preface, the reader who is a newcomer to the field might be too easily misled into believing that all computers have been designed by Boolean algebraists. The main criticism of the book is that it is not so comprehensive as its title suggests, since it is concerned solely with synchronous serial machines. The author may be forgiven for preferring his title to be succinct rather than accurate and clumsy, but the limitations, though mentioned in the preface and in the body of the text, are not given sufficient prominence. Within these limitations, the work is both comprehensive and well balanced.

Digital Computer Components and Circuits is described by its author as concentrating on digital concepts rather than on detailed design techniques, and he gives several good

reasons for this, including the fact that the detailed design techniques have been adequately covered in other textbooks. The fact is, however, that, even without these, this book contains just over 500 pages of the most comprehensive detail on digital circuit techniques, and there is practically none of it that could have been sacrificed without considerable loss. Half the book is concerned with systems of circuit logic and contains a chapter devoted to each of the subjects of diode, vacuum-tube, transistor, and magnetic-core systems. The other half covers storage systems just as comprehensively, and mentions some other devices, including analogue-digital and digital-analogue convertors. Units which are sometimes described as 'auxiliary' receive rather brief attention, and in the present stage of computer development it might be thought that there is some lack of balance in a work which devotes eight pages to magnetic-tape units and twenty to the Williams tube; but this is only a minor criticism.

A specially valuable feature of both books is the very comprehensive bibliography which appears at the end of each chapter.

V. V. SOLODOVNIKOV and others
TRANSIENT RESPONSE FROM FREQUENCY RESPONSE

INFOSEARCH. 1958. 193 PP. £2 2S.

THIS book, published by Infosearch, is the translation into English of a Russian work of 1955 on control-system computations. It will interest many English-speaking engineers to see this example of Russian technological literature, which illustrates very well the vigour of the Soviet Union's technological effort. It will perhaps help to make the Sputnik more creditable.

The form of the book is unusual. Two-thirds of its pages are occupied by a set of numerical tables and charts useful in computing the transient responses of linear systems. The main intended application is to control-system computations, but the charts and tables are, of course, applicable to other linear systems. The first third of the book is a concise formal statement of the mathematical basis for the tables, with examples illustrating their use in computation. It is not a textbook in any more general sense.

A main set of tables provides in numerical form the transient response to unit-pulse or unit-function inputs corresponding to frequency responses of trapezoidal form. The transient response for any form of frequency response and for any input time-function is obtainable by regarding the actual frequency-response diagram, and the time function of input, as made up of trapezoidal components. The responses corresponding to the separate components can then be added. Many other charts and tables are included, such as those usually known in this country as M-charts, which apply to various computations in the same general field. Ingenious suggestions are made by the authors for applying the charts and tables to the solution of problems other than those for which they are primarily devised.

The book will be of direct use, apart from general interest, mainly to those who have actually to compute transient responses for complex linear systems. The examples given by the authors deal with such applications as an auto-piloted aircraft, an electro-hydraulic servo, and the speed control of a hydraulic turbine. The mathematical introduction is very competent and will be useful for reference, but it is too concise to be of use as a textbook.

The existence of this work in the Soviet Union in 1955 indicates the thoroughness and depth with which the tools of technological progress are being fashioned in that country. It is hard to see how a similar book could make its appearance in the West. It is the kind of contribution that can only be expected from a high-level, extremely specialized technical institute strong both in mathematics and in computational resources and little concerned with publication economics.

E. SPENKE
ELECTRONIC SEMICONDUCTORS

MCGRAW-HILL. 1958. 402 PP. £4 5S. 6D.

THIS translation of the second German edition of Spenke's *Elektronische Halbleiter* contains an additional section on junction capacitance, and problems have been added to each chapter.

The book is divided into two separate parts, each complete in itself, of which the first deals with the conduction mechanism of electronic semiconductors and the physics of rectifiers and transistors. The subjects treated follow the now familiar pattern: the band model, the distinction between metals and semiconductors, the effects of impurities, the concept of the hole, rectifiers, junctions, transistors and so forth. At this point the reader may begin to wonder whether yet another book on these topics was really needed. However, further reading will quickly reassure him, for Spenke's treatment is altogether exceptional in its clarity and rigour. No attempt is made to include the latest experimental results on new types of transistor, and the emphasis throughout is on fundamental concepts and processes. For example, a complete chapter is devoted to an explanation of exactly what is meant by the effective mass of an electron in a solid and by the concept of a hole.

This part of the book is addressed to the reader who is primarily interested in experimental work but who wishes to understand the basis of modern theories of semiconductor devices. He is assumed to be familiar with the ideas of quantum mechanics and the elements of Fermi statistics but is not required to plough through a mass of detailed calculations.

The second part of the work deals with the fundamentals of semiconductor physics at a much higher level, though even here detailed calculations are largely avoided. A short chapter on the methods of approximation which have been used in the theory of the hydrogen molecule serves as an introduction to a very long chapter—about one-third of the whole book—on the band model. The Bloch and the Brillouin approximations are considered in detail, and the results obtained from them are compared. Other sections are devoted to such topics as the influence of imperfections and lattice vibrations on the motion of an electron in a crystal; the effects of static and alternating electromagnetic fields; the Zener effect; etc. At every stage, the assumptions involved in the model are critically examined and their consequences pointed out. This chapter supplies a wholesome corrective for any who may have been tempted to look on the band model as an exact theory.

The remainder of the book contains three chapters dealing respectively with Fermi statistics, the dynamic approach to impurity equilibria, and surface and contact phenomena. Here again, clarity of thought and exposition are outstanding.

This is a wholly admirable book which can be most warmly recommended.

E. OPENSHAW TAYLOR

THE PERFORMANCE AND DESIGN OF A.C. COMMUTATOR MOTORS

PITMAN. 1958. 350 PP. £2 5S.

THIS is a very comprehensive work on single-phase and 3-phase a.c. commutator machines. It is a companion volume to Clayton's *Performance and Design of D.C. Machines* and Say's *Performance and Design of A.C. Machines*, and the author claims that these three books between them cover the whole range of electrical machinery. For this reason, the book under review includes discussions of machines without commutators, such as the single-phase induction motor, the shaded-pole motor and the capacitor motor. The volume is one of the publisher's engineering-degree series and is therefore aimed at undergraduates.

While the text does not seem to leave out anything that is important, it does contain obsolete material. The unfortunate student has to read about types of machines which have been abandoned for many years without any indication that they are obsolete and why. It may be argued that there is academic value in the study of these machines, but this argument can carry little weight when one considers the gross overloading of the average engineering syllabus. Apart from this criticism, there can be nothing but praise for the thoroughness with which the subject has been dealt with.

The book is in four parts. The first part considers general principles and has a very good chapter on commutation. The second part covers commutator machines used with induction motors for modifying the speed or power factor. Part 3 deals with 3-phase commutator motors of various types. Part 4 is the longest and includes all single-phase commutator machines, as well as the special induction motors mentioned above. There are two appendices, one on harmonic analysis and the other on the establishment of circle diagrams.

A very good feature of the work is the collection of exercises at the end of each chapter. These exercises all involve some numerical calculation, and the answer to each question is given at the end of the book.

This is a book which can be thoroughly recommended to all students of electrical engineering.

C. G. WILSON

ELECTRICITY AND MAGNETISM

THE ENGLISH UNIVERSITIES PRESS. 1958. 538 PP. 21S.

THIS book aims to meet the needs of students taking the advanced and scholarship level examination in physics of the General Certificate of Education and of those students preparing for open scholarships to the universities. The author uses what is generally regarded as the 'classical' approach, claiming that this has the advantage of 'closer alliance with historical development'. Elementary electrostatics and magnetism are developed from the point-charge and point-pole concepts. The more difficult experimental technique associated with electrostatics and those experiments associated with magnetostatics which, although not difficult, are often allowed to assume an exaggerated importance, are relegated to a final chapter.

Following the introduction, the treatment proceeds with electric currents, circuits, thermal and electrolytic phenomena, electromagnetic induction, alternating currents and circuits, generators and motors, electron physics, X-rays, radioactivity and atomic structure, and nuclear physics. The whole represents a well balanced and generally modern treatment.

M.K.S. rationalized units are used throughout, and their introduction and development are altogether praiseworthy. That a generally conventional treatment of electricity and magnetism can be seen to proceed naturally with such units should do much to explode the myth that their use is inimical to a classical and academic approach. The author, in fact, may have done himself less than justice by saying in his preface that the method of their introduction has been 'chosen deliberately . . . in contrast to the ideas expressed by leading members of The Institution of Electrical Engineers'. Differences of opinion may exist among such members on detailed matters of unit usage, but Mr. Wilson's treatment will find general acceptance. The benefits to students brought up with a single consistent unit system which is now almost universal in university and other advanced electrical-engineering studies cannot but be helpful.

The text is liberally illustrated with line diagrams. Some of these would have been more satisfying artistically had the lettering sizes been more carefully chosen, and had sine waves been drawn with less recourse to a straight edge. In those sections dealing with the technology of the subject, some attention to current practice is desirable in later editions. Thus the hot-wire ammeter is not one of 'the common a.c. ammeters'; the diagram (11.22) and associated explanation of induction-motor action call for attention, as does the diagram of the two-stage amplifier (12.20); the notation is generally good but could be improved. These are, however, minor criticisms of a valuable contribution to the literature.

S. G. STURMEY

THE ECONOMIC DEVELOPMENT OF RADIO

DUCKWORTH. 1958. 284 PP. 30S.

THIS book sets out to discover the economic reasons behind the successful exploitation of radio for communication (marine and fixed point-to-point) and entertainment. The author argues that innovations are the life-blood of successful economic progress in any industry, and he makes a clear distinction between invention and innovation—but not until the final chapter is reached! These definitions are required at the beginning, if the author's presentation of the history of radio is to be fully understood. An invention is 'the discovery of a new device, a new technique' whereas an innovation is 'a new application' to serve commercial purposes. Innovation, in the author's mind, is essentially a generator of economic activity and the final test is 'profit' or, in the case of the nationalized industries, is 'the difference between social benefit and social cost'. The difficulties of determining social benefit and cost are stressed. Two main types of innovation are postulated: revolutionary and evolutionary. With the first, the change is clear-cut, producing conditions which bear little resemblance to those previously obtaining; the application of radio to marine communication is cited as an example because it resulted in the birth of a completely new industry. The evolutionary innovation causes a major variation which still has its roots in the past, and television broadcasting comes within this category.

The author considers that competition is essential if stagnation is to be avoided, and he sees bursts of activity set off by revolutionary or evolutionary innovations, brought about by the entry of a new rival into the field. Thus marine radio was held back until the expiry of the master patents

allowed rivals to make a successful challenge based on their own technical progress. Once the rivals have been absorbed, a period of technical somnolence prevails until another rival disturbs the serenity. The background of radio point-to-point communication development is shown to be a persistent industrial company versus frustrating government action and scepticism. Broadcasting is seen as a combination of monopoly for the service and economic freedom for the industry making receiving sets. The resulting industrial structure, which fell short of the economist's competitive ideal owing to such factors as the technical ignorance of the buyer, is fully analysed. The author stresses the importance of the circuit-development work carried out by some valve manufacturers and made freely available to the 'assembler' part of the industry, and he shows that this materially helps at this level to keep competition in being. There are some interesting observations on the significance of patents in economic activity.

The author has made full use of the resources of the Institution library in digging out the history of radio communication, and there are adequate references at the end of each of the 12 historical chapters. The 13th presents a good summary of his economic conclusions. One has two minor criticisms: there are one or two places, notably on the first page of chapter 1, where the English phraseology needs some attention; and in chapter 2 the impression is given that only one valve manufacturer was supplying circuit data to set manufacturers on a large scale. There was at least one other.

The book can be read with interest and profit by all engaged in the radio industry.

D. D. STEPHEN

SYNCHRONOUS MOTORS AND CONDENSERS

CHAPMAN AND HALL. 1958. 500 PP. £3

THIS must be the largest and most comprehensive book on the synchronous motor that has appeared so far. It contains a great deal of information about the control and application of this machine, which is being more and more widely employed in industry. The technology of the synchronous motor has remained rather esoteric. Everyone, in contrast, knows all about the induction motor, that maid-of-all-work when electric drive is in question. This book thus fills a gap in the literature of electrical machines, so that its appearance should be welcomed.

Much of the material concerns operation, performance and control. The normal power-factor-corrective function of the synchronous motor, known to every student of the art, does not concern the author for very long. He passes to transient behaviour and, particularly, to starting, which is dealt with fully and at length, with occasional excursions into fairly simple analyses based on the reactances of the machine. Protection, application and the selection of equipments (with several illustrative examples, such as ship propulsion) are well discussed. A final chapter is devoted to synchronous condensers, considerably extending the sparse literature on this useful and comparatively novel subject.

In coverage and usefulness, especially for the operating engineer, the book is to be highly commended. Would that it were easier to read. In this respect the author is his own worst enemy: he knows too much about synchronous machines!

A well-known bishop once said, 'If I want to correct my ignorance of a sociological subject, I write a book about it'. There is truth here, for the thought and research and weighing-up in such authorship give a first-hand appreciation of the difficulties that the subject will present to the learner. Most technical books are, of course, written by experts. But the *best* technical books are by authors who can put their minds back to the learner stage. In the first chapters of 'Synchronous Motors and Condensers' the author is unsuccessful, for his methods show the shorthand of the expert rather than the exposition of the interpreter. What is background to him is foreground—and perhaps rough going—to his readers. He is much more compelling later, when dealing with control and application.

The book is pleasantly printed, and the numerous line drawings are clear. In one or two cases their meaning is not comparably clear. Thus the sine waves of flux, current and so on in Fig. 2.1 have no marked axis, and a naked arrow points obscurely to the left. Fig. 2.7 is incorrect in its representation of quadrature-axis flux. The paragraphing and the arrangement of the material are often haphazard.

Technical writing is for information, not to stimulate the emotions. Yet *style* is just as necessary as it is in essay or fiction. Facts are pedestrian, but they can be marshalled and paraded, and with an occasional turn of phrase made more easy to digest. This author has little feeling for words and less for style. Forty-word sentences without punctuation, the use of the same word with different meanings in the same sentence, the deadly succession of and . . . and . . . and . . ., hammer the reader into a coma. One must be insensitive (or take a literary anaesthetic) to derive with enjoyment the considerable intrinsic value of this book.

THE THEORY OF MARGINAL COST AND ELECTRICITY RATES

THE ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION. 1958. 79 PP. 6s.

THE first part of this publication (approximately three-quarters of the whole) is a study of marginal-cost pricing by a working party appointed by the group of experts on electricity rates nominated by the member countries. The result is an extremely confusing document, a confusion which cannot entirely be blamed on the faulty translation. The treatment is in the highest degree 'academic', in the worst sense of the word, but without the precision which should result from so elaborately scientific an approach. Thus increment cost is defined as 'the average cost, for accounting purposes, of an actual "block" of investment'. Whatever the meaning attached to the term, 'cost of investment', it can hardly include fuel cost, yet this is certainly a part of the increment cost.

Almost the only practical suggestion made is that, instead of installing additional capacity to meet a growing load, the price of electricity during peak hours should be increased sufficiently to keep the demand at a level which can be met. There is nothing new in this idea: what is lacking is a quantitative workable application. While all would agree that consumption at a given time is affected by price, the crucial question is 'how much?', and unfortunately all the price-demand curves shown are purely hypothetical.

The second part consists of statements, ranging in length from a single paragraph to several pages, by ten member countries, of the principles followed in their electricity tariffs. Little use appears to be made of marginal-cost principles, but there is evidently a considerable similarity between the different tariff forms, and this part could well have been expanded into an over-all comparison of European electricity rate structures.

*Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

ALGER, P. L. 517

Mathematics for Science and Engineering. Based on Engineering Mathematics by C. P. Steinmetz*

London, McGraw-Hill, 1957. pp. xi, 360. 23 × 15 cm. £2 1s. 6d.

This book follows the plan and incorporates about half of the material in Steinmetz's 'Engineering Mathematics', with additional material on the calculus, differential equations, probability and electric-circuit theory. It is intended to supplement the high-school and college mathematical programme, leading on from arithmetic, trigonometry, algebra, etc., in successive steps.

BROUGHTON, H. H. 621.873

Electric Cranes. A Manual on the Design, Construction, Application and Operation of Electric Cranes*

London, Spon, 1958. pp. xiii, 511, xxx. 25 × 19 cm. £7 10s.

The third edition of this standard work has been entirely rewritten and re-illustrated to take account of progress in design, construction and applications since the previous edition appeared 35 years ago. This book will be reviewed in a future issue.

BURNHAM, T. H., and HOSKINS, G. O. 658

Elements of Industrial Organization. 6th ed.*

London, Pitman, 1958. pp. v, 330. 22 × 14 cm. 21s.

This well known book is intended to give the engineer an indication of the outside economic influences which affect the organization in which he is employed. It also covers the syllabus of the subject for The Institution's examination for graduate membership. In this carefully revised edition statistics have been brought up to date.

DAVENPORT, W. B., and ROOT, W. L. 621.396.8

An Introduction to the Theory of Random Signals and Noise*

London, McGraw-Hill, 1958. pp. ix, 393. 24 × 16 cm. £3 17s. 6d.

An introduction to probability theory and statistics, a discussion of the statistical properties of the Gaussian random process, a study of the results of passing random signals and noise through linear and non-linear systems, and, finally, an introduction to the statistical theory of the detection of signals in the presence of noise.

DORFMAN, R., SAMUELSON, P. A., and SOLOW, R. M. 658

Linear Programming and Economic Analysis

London, McGraw-Hill, 1958. pp. ix, 527. 23 × 15 cm. £3 17s. 6d.

Mathematicians have developed a set of theories and procedures closely related to the maximization problems of economic theory. They are known as linear programming, i.e. the analysis of problems in which a linear function of a number of variables is to be maximized (or minimized) when those variables are subject to a number of restraints in the form of linear inequalities. This book gives the economist who is not an accomplished mathematician a broad introduction to this new approach. Reviewed in the August Journal, p. 461.

ETTINGER, G. M. 621.318.42

Magnetic Amplifiers. New ed., reset*

London, Methuen, 1957. pp. xi, 102. 17 × 11 cm. 9s. 6d.

In this edition chapters have been included on half-wave fast-response magnetic amplifiers and on microwave applications of ferrites, and the chapter on computer elements has been extended. This book is reviewed on p. 512.

EVERDELL, M. H. 536.7

Fundamental Thermodynamics for Engineers

London, English Universities Press, 1958. pp. xii, 201. 22 × 14 cm. 25s.

Covers the thermodynamics required by the student reading for an engineering degree. Provides a detailed account of the first and second laws of thermodynamics and the meaning and use of the thermodynamic functions.

FELICI, N. J. 621.319.3

Elektrostatische Hochspannungs-Generatoren und ihre industrielle Anwendung (Electrostatic High-Voltage Generators and their Industrial Application)

Karlsruhe, Verlag G. Braun, 1957. pp. 111. 21 × 15 cm. £2 2s.

GENERAL ELECTRIC COMPANY LIMITED 621.395.645

An Approach to Audio Frequency Amplifier Design

London, General Electric Co., 1957. pp. x, 126. 23 × 15 cm. 10s. 6d.

A convenient presentation of the essential details and circuit diagrams of a comprehensive range of audio-frequency amplifiers, each of which has been built and tested.

HARTREE, D. R. 518.5

Numerical Analysis. 2nd ed.

Oxford, Clarendon Press, 1958. pp. xvi, 302. 24 × 16 cm. £2 2s.

An introduction to the theory and practice of carrying out numerical calculations of various kinds. Considers finite differences, interpolation, integration and differential equations.

McFARLAND, T. C. 621.313.3

Alternating Current Machines*

London, Van Nostrand, 1948. pp. ix, 540. 24 × 16 cm. £2 12s. 6d.

Based on lectures to college students. A knowledge of alternating-current theory is assumed, since the machines are considered as equivalent circuits. Discusses single-phase then special-purpose transformers, induction motors, synchronous machines, power convertors, including mechanical types, and single-phase motors.

McKOWN, R. 347.7

Comprehensive Guide to Factory Law. A Classified Guide to the Requirements of the Factories Acts and other Legislation affecting Factory Occupiers*

London, Chantry Publications, 1954. pp. 112. 28 × 21 cm. 21s.

MEARES, J. W., and NEALE, R. E. 621.3

Electrical Engineering Practice. A Practical Treatise for Electrical, Civil and Mechanical Engineers. Vol. I. 6th ed.*

London, Chapman and Hall, 1958. pp. xiii, 716. 22 × 13 cm. £3.

While the general plan of this book remains unaltered, the previous edition, published in 1938, has been thoroughly revised by a panel of experts (the surviving author having died in 1948) to take account of recent advances in equipment and materials. It deals with definitions, materials, measurements, the generation and sale of electrical energy, and transmission and control, including switchgear and protection. It was reviewed in the July Journal, p. 402.

NETSCHERT, B. C. 662.6

The Future Supply of Oil and Gas. A Study of the Availability of Crude Oil, Natural Gas and Natural Gas Liquids in the United States in the Period through 1975

Baltimore, Johns Hopkins Press, 1958. pp. xiv, 134. 21 × 14 cm. 24s.

O'DEA, W. T. 93 : 628.9

The Social History of Lighting*

London, Routledge and Kegan Paul, 1958. pp. xiii, 254. 25 × 16 cm. £2 2s.

Traces the history of lighting for the home, for work, travel, the theatre, and in fact all occasions, from the earliest rush light to electric light. It is, as the title states, a social history rather than a technical account of invention and development. This book will be reviewed in a future issue.

PARTRIDGE, G. R. 621.317.7

Principles of Electronic Instruments*

Englewood Cliffs, Prentice-Hall, 1958. pp. xiv, 393. 23 × 15 cm. £3 14s.

A review of the possibilities of electronic techniques for measuring electrical and non-electrical quantities.

PERRINE, J. O. 517

Physics and Mathematics in Electrical Communication

New York, John F. Rider, 1958. pp. 261. 29 × 22 cm. $7.50

An introduction to the geometric and trigonometric background of hyperbolic functions is followed by examples of their application in electrical communication.

PULLEN, K. A. 621.385

Conductance Curve Design Manual

New York, Rider, 1958. pp. xiv, 114. 28 × 21 cm. $4.25

Gives dynamic as well as static characteristics of a number of triodes, tetrodes and pentodes to assist the designer of RC amplifiers.

RAWER, K. 621.396.11

The Ionosphere. Its Significance for Geophysics and Radio Communications*

London, Crosby Lockwood, 1958. pp. 202. 23 × 15 cm. £2 2s.

Translated from the original German, this book describes the various methods of observation—sounding by radio-wave reflections, spectroscopic, geomagnetic and other means, and rocket ascents—and discusses the observations obtained and the conclusions based on them. It was reviewed in the August Journal, p. 463.

RENTON, R. N. 621.39

Telecommunication Principles (in M.K.S. Units)*

London, Pitman, 1958. pp. xiii, 446. 25 × 19 cm. £2 5s.

Covers the syllabus for the City and Guilds of London Institute examinations in Telecommunication Principles, Grades I, II and III. Based on the rationalized system of M.K.S. units, it includes worked examples.

SPREADBURY, E. A. W. 621.397.62

Television Receiver Servicing. Vol. 2.* Receiver and Power Supply Circuits. 2nd imp.

London, Iliffe, 1957. pp. 354, vi. 21 × 14 cm. 21s.

Deals in a practical way with the localization of faults in the various stages of a television receiver. Vol. 1 deals with time-bases and their associated circuits. This volume deals with all the other sections of a receiver, with interference suppression and with multi-channel tuning systems. The main change in this edition is in the chapter on aerials, which has been enlarged to include Band III and dual-band aerials.

STURMEY, S. G. 93 : 621.396

The Economic Development of Radio*

London, Gerald Duckworth, 1958. pp. 284. 22 × 14 cm. 30s.

Sets out to determine the conditions in which progress has occurred in the industry—considering marine radio, point-to-point communication and broadcasting—and studies the factors leading to the adoption or rejection of new ideas. It is reviewed on p. 515.

TUTTLE, D. F. 538.551

Network Synthesis. Vol. 1

London, Chapman and Hall, 1958. pp. xv, 1175. 23 × 15 cm. £9 8s.

This volume deals with steady-state behaviour of 2-terminal networks. A second volume on 4-terminal networks is proposed. The work is based on lectures to students.

WOOD, W. S. 621.313

Theory of Electrical Machines*

London, Butterworth, 1958. pp. x, 317. 25 × 15 cm. £2 10s.

Suitable for final-year students. It treats the subject in a general fashion without departing from the conventional methods of analysis employing equivalent circuits and vector diagrams. There is an appendix on the fundamentals of design. M.K.S. units are used.

YOUNG, A. P., and GRIFFITHS, L. 629.11 : 621.3

Automobile Electrical Equipment. Theory and Practice for Students, Designers, Automobile Electricians and Motorists. 6th ed.*

London, Iliffe, 1958. pp. 398. 22 × 14 cm. 30s.

This edition draws attention to recent developments, including the use of p-n junction-type rectifiers, impulse starters, automatic timing control, and igniters for gas turbines.

OTHER PUBLICATIONS

ACCADEMIA NAZIONALE DEI LINCEI

I Modelli nella Tecnica. Atti del Convegno di Venezia 1–4 Ottobre 1955 (Models in Technology. Proceedings of the Conference held at Venice 1–4 October 1955) Vols. I and II

Rome, Accademia Nazionale dei Lincei, 1956

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS—ELECTRICAL ENGINEERING DEPARTMENT

Eleventh Annual Conference for Protective Relay Engineers. April 14–16, 1958

Texas, A. & M. College, 1958. pp. 240. 29 × 23 cm

ALUMINIUM DEVELOPMENT ASSOCIATION

A Symposium on Aluminium and its Alloys in Electrical Engineering. Convened by the Aluminium Development Association and held at The Institution of Electrical Engineers, London, May 16 and 17, 1957

London, A.D.A., 1957. pp. 370. 21·5 × 15 cm. 20s.

BRITISH BROADCASTING CORPORATION

Analysis and Measurement of Programme Levels:
Investigation of Extreme Values of Sound Pressure by D. E. L. Shorter and W. I. Manson
A Description of an Optical Instrument for Monitoring Sound Signals by E. R. Wigan

London, B.B.C., 1958. Engineering Division Monograph No. 16. pp. 31. 28 × 22 cm. 5s.

The Design of a Linear Phase-Shift Low-Pass Filter

London, B.B.C., 1958. Engineering Division Monograph No. 17. pp. 23. 28 × 22 cm. 5s.

ELECTRICITY COUNCIL

The 1955 Sample Survey of Domestic Consumers
London, Electricity Council, 1958. Utilisation Research Report No. 7. pp. 23. 28 × 21·5cm

The History and Philosophy of Science and Technology. Eight Lectures
London, Electricity Council, 1958. pp. 139. 21 × 14cm. 9s.

PHYSICAL SOCIETY

Reports on Progress in Physics. Vol. xxi (1958)
London, Physical Society, 1958. pp. iv, 383. 25 × 17cm

SELF, H.

Some Implications of Modern Science
London, Privately printed, 1958. pp. 18. 21 × 14cm. 1s. 6d.

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review or special article. Where given, the date in capitals refers to the month in which a paper was published individually

PART A. POWER ENGINEERING (AUGUST 1958)

See the Journal for August 1958, p. 464

PART B. RADIO AND ELECTRONIC ENGINEERING (SEPTEMBER 1958)

H. W. MELVILLE, D.SC., F.R.S. PAPER NO. 2616 The Forty-Ninth Kelvin Lecture on **Chemical Structure of High Polymers and their Physical Behaviour**

F. R. AXWORTHY. PAPER NO. 2682 M **Industrial Electrical Measuring Instruments** (A Review of Progress) *September 1958*

F. C. WIDDIS, B.SC.(ENG.). PAPER NO. 2695 M **Scientific Electrical Measuring Instruments** (A Review of Progress) *September 1958*

L. C. JESTY, B.SC. PAPER NO. 2540 R, FEBRUARY 1958 **The Relation between Picture Size, Viewing Distance and Picture Quality** *April 1958*

I. F. MACDIARMID AND B. PHILLIPS, B.SC.(ENG.). PAPER NO. 2687 R **A Pulse-and-Bar Waveform Generator for Testing Television Links** *September 1958*

K. W. CATTERMOLE, B.SC. PAPER NO. 2474 R, DECEMBER 1957 **Efficiency and Reciprocity in Pulse-Amplitude Modulation: Part 1—Principles** *May 1958*

J. C. PRICE, B.SC. PAPER NO. 2475 R, DECEMBER 1957 **Efficiency and Reciprocity in Pulse-Amplitude Modulation: Part 2—Testing and Applications** *May 1958*

K. W. CATTERMOLE, B.SC. PAPER NO. 2577 R, MARCH 1958 **Transistor Pulse Generators for Time-Division Multiplex** *May 1958*

Discussion on **Servo-Operated Recording Instruments** before the South Midland Radio and Measurement Group

E. J. HOOKER, M.A., PH.D.(ENG.). PAPER NO. 2710 R **The Factors influencing the Use of Pneumatic Methods for the Location of Sheath Faults in Pressurized Telephone Cables** *September 1958*

J. ALLISON, B.SC.(ENG.), PH.D., AND F. A. BENSON, D.ENG., PH.D. PAPER NO. 2689 R **Measurement of Impedance and Attenuation of a Cable through an Arbitrary Loss-Free Junction** *September 1958*

M. LEHMAN, B.SC., PH.D. PAPER NO. 2693 M **Short-Cut Multiplication and Division in Automatic Binary Digital Computers** *September 1958*

Discussion on **The Application of Printed-Circuit Techniques to the Design of Microwave Components** before the South-East Scotland Sub-Centre

PART C. MONOGRAPHS (SEPTEMBER 1958)

(Reviews of monographs are not published in the Journal)

PROF. A. L. CULLEN, PH.D., B.SC., AND T. H. BARTON, PH.D., B.ENG. NO. 283 U, JANUARY 1958 **A Simplified Electromagnetic Theory of the Induction Motor, using the Concept of Wave Impedance**

E. W. LEE, B.SC., PH.D. NO. 284 M, FEBRUARY 1958 **Eddy-Current Losses in Thin Ferromagnetic Sheets**

J. BROWN, M.A., PH.D. NO. 285 R, FEBRUARY 1958 **A Theoretical Analysis of Some Errors in Aerial Measurements**

P. HAMMOND, M.A. NO. 286, FEBRUARY 1958 **Electromagnetic Energy Transfer**

A. E. KARBOWIAK, PH.D., B.SC.(ENG.). NO. 287 R, FEBRUARY 1958 **Microwave Aspects of Waveguides for Long-Distance Transmission**

J. P. ELLINGTON, B.SC., AND H. MCCALLION, B.SC., PH.D. NO. 288 M, FEBRUARY 1958 **The Determination of Control-System Characteristics from a Transient Response**

G. H. METSON, M.C., PH.D., M.SC., B.SC.(ENG.). NO. 289 R, FEBRUARY 1958 **The Conductivity of Oxide Cathodes**

E. HANDS, M.SC. NO. 290 R, FEBRUARY 1958 **A Rectifier Modulator with Stable Low Carrier-Leak**

J. E. FLOOD, PH.D. NO. 291 R, FEBRUARY 1958 **Noise-Reducing Codes for Pulse-Code Modulation**

O. P. D. CUTTERIDGE, M.SC.(ENG.), PH.D. NO. 292 R, FEBRUARY 1958 **Some Optimum Four-Terminal Networks having Given Input and Output Shunt Capacitances**

R. HANCOX, B.SC.(ENG.), PH.D. NO. 293 S, MARCH 1958 **The Interpretation of the Results of Impulse Breakdown Tests**

H. NICHOLSON, M.ENG., AND J. W. LYNN, M.SC. NO. 294 S, MARCH 1958 **The Economic Loading of Transmission Systems**

J. W. LYNN, M.SC. NO. 295 S, MARCH 1958 **Tensor Analysis of Electrical Machine Hunting**

J. FIGANIER, B.SC., AND E. A. ASH, PH.D. NO. 296 R, MARCH 1958 **Intrinsic Directional Coupler Using Elliptical Coupling Apertures**

H. S. HEAPS, B.SC., M.A., AND M. R. MCKAYE, B.E. NO. 297 R, MARCH 1958 **Optimum Network Functions for the Sampling of Signals in Noise**

A. R. BILLINGS, B.SC., PH.D. NO. 298 R, MARCH 1958 **The Rate of Transmission of Information in Pulse-Code-Modulation Systems**

Z. GODZIŃSKI. NO. 299 R, APRIL 1958 **The Use of Equivalent Secondary Sources in the Theory of Ground-Wave Propagation Over an Inhomogeneous Earth**

J. BROWN, M.A., PH.D., AND J. S. SEELEY, B.SC.(ENG.), PH.D. NO. 300 R, APRIL 1958 **The Fields Associated with an Interface between Free Space and an Artificial Dielectric**

J. BROWN, M.A., PH.D. NO. 301 R, APRIL 1958 **A Generalized Form of the Aerial Reciprocity Theorem**

C. V. JONES, M.ENG., B.SC. NO. 302 U, APRIL 1958 **An Analysis of Commutation for the Unified-Machine Theory**

T. M. H. REENSKAUG AND J. H. WESTCOTT, PH.D. NO. 303 M, APRIL 1958 **Design of Sampling Servo Systems in the *z*-Plane**

N. KESAVAMURTHY, M.A., M.SC.(TECH.), AND R. E. BEDFORD, B.SC., PH.D. NO. 304 U, MAY 1958 **The Circuit Theory and Calculations of Polyphase Induction Machines**

J. W. HEAD, M.A., AND C. G. MAYO, M.A., B.SC. NO. 305 R, MAY 1958 **The Response of a Network to a Frequency-Modulated Input Voltage**

A. J. O. CRUICKSHANK, B.SC., PH.D. NO. 306 M, JUNE 1958 **An Exact Theory of *N*-Component Steady-State Operators for Linear Circuits**

R. SPENCE, B.SC.(ENG.), AND A. R. BOOTHROYD, PH.D. NO. 307 R, JUNE 1958 **On the Discrimination of a Synchronized Oscillator against Interference accompanying the Synchronizing Signal**

P. D. AYLETT, PH.D., M.SC.(ENG.), WH.SC. NO. 308 S, JULY 1958 **The Energy-Integral Criterion of Transient-Stability Limits of Power Systems**

M. J. SOMERVILLE, B.SC., AND D. P. ATHERTON, B.ENG. NO. 309 M, JULY 1958 **Multi-Gain Representation for a Single-Valued Non-Linearity with Several Inputs, and the Evaluation of their Equivalent Gains by a Cursor Method**

THE ENGINEERING INSTITUTIONS' EXAMINATION (PART I) APRIL 1958

THERE are seven institutions participating in the Engineering Institutions' Part I Examination:

THE INSTITUTION OF CIVIL ENGINEERS
THE INSTITUTION OF MECHANICAL ENGINEERS
THE INSTITUTION OF ELECTRICAL ENGINEERS
THE INSTITUTION OF MUNICIPAL ENGINEERS
THE INSTITUTE OF MARINE ENGINEERS
THE INSTITUTION OF GAS ENGINEERS
THE NEW ZEALAND INSTITUTION OF ENGINEERS

BRITISH ISLES

The following have satisfied the examiners in the compulsory subjects of Part I (Mathematics; Applied Mechanics; Heat, Light and Sound; Principles of Electricity; and Engineering Drawing):

ABAYAWARDANA, Hettiarachi Gamini Dias
ALDRIDGE, Thomas Henry
ALEXANDER, Francis[2]
AMIN, Hariprasad Mohammad[2]
ANSELL, George Verdun[1]
ARCHER, Peter[2]
ATANE, Enoch Ojeikhoa
ATKINSON, Richard
BAILEY, Brian Arthur
BALDWIN, Derek Patrick[2]
BEVAN, John William
BIDDLECOMBE, Derek Alan
BIRTWISTLE, Peter Lee[2]
BOARDMAN, Edward Tunde
BOLTON, Grahame John
BRADLEY-SMITH, Graeme Charles[2]
BRANSON, Roy Edwin
BROWN, Donald Maurice
BURTON, Anthony Richard[2]
BURTON, David Archibald
BUTLER, John Anthony
CALDER, John[2]
CAMPBELL, Allan Sime[2]
CANN, Alan Stanley[2]
CARNIE, William Colin Greig[2]
CHERRY, Ian Stuart[2]
CLEGG, Paul[2]
COLLEY, Derek[2]
COOK, Alec William[2]
COSTELLO, William Joseph
CROSS, David Brian[2]
DAS, Satya Jiban
DAVIES, Thomas Malcolm[2]
DEAN, John[2]
DE SILVA, Uswattage Don Henry[2]
DEVENISH, Donald Mathieson[1]
DIAMOND, Liam[1]
DOWELL, Walter Roy[2]
ELVER, John[2]
EVANS, Leslie William[2]
EWART, William George
FORTON, Harry Graham
FOWLE, Thomas[2]
GADE, Gavin Derrick
GIBB, John McLean
GLEAVE, Reginald Victor[2]
GODAVITARNE, Don Chandra Angulugahagamage
GOODLIFFE, Michael Philip
GRIFFITHS, Henry Gwyn[2]
HAREWOOD, Francis Charles[2]
HARRISON, Derek[2]
HARRISON, Kenneth Peter[2]
HAWKER, Philip Albert Edward
HAWKES, John
HAWKINS, William Edward
HERATH, Herath M. L. H. M.
HEWLETT, Bernard James
HUDALIGE, Somapala
HUSAIN, Syed Hashim[1]
HUSAIN, Zaheer
IDOWU, Charles Olatunji[3]
IRVING, Alan John Murray
JAIN, Ratan Lal[1]
JAMES, Peter Wilson[2]
JONES, Wyndham Charles[3]
KEAL, Frank Edward William
KIDD, Simon George Crozier[2]
KING, Reginald Alfred
KRZYWIEC, Kazimierz Jerzy
KYTE, William[2]
LEARY, John Jamieson[2]
LEDINGHAM, Leslie William Clark[3]
LEWIS, Alfred Brian[2]
LEWIS, John Noel[2]
LEWIS, Michael Geoffrey[2]
LOMAS, Thomas[1]
McCOURT, Roy[2]
McCREADIE, Anthony Robert[1]
McKEE, John Peden[2]
McKINLAY, Ian[2]
McNEIL, Ian
MADDOX, Peter[3]
MALTON, John Michael[2]
MARTIN, Joseph[2]
MATTINGLY, Christopher Thomas
MAYBURY, Francis Patrick
MEKITARIAN, Noel John
MOORE, Bryan
NARAYAN, Doddaballapur Satya
OCATHAIN, Seamus
O'FARRELL, Patrick Sylvester Andrew
OMIDIJI, Ayoola
OZAKAT, Ergun
PEARCE, Michael Henry[3]
PHILLIPS, John Arnaud[1]
PRIESTLEY, Michael Harold[1]
QUEEN, Charles Geoffrey
RANADE, Suresh Parashuram
REDMOND, Paul[2]
RELPH, Robert Leslie[2]
RIGBY, George Anthony[2]
ROBERTS, Graham
RODGERS, Michael James Arthur[3]
ROWLANDS, Hugh David[3]
SAHAI, Devendra
SAUNDERS, Donald[2]
SCHMIDT, Geoffrey Michael[2]
SHAKESPEARE, Keith John[2]
SHELTON, Eric John[2]
SHORT, Ian James[2]
SIMMONS, Keith
SINGH, Bakshi Brijindra
SLANEY, John Philip[2]
SMITH, Peter Dennis[2]
STACK, James Michael
STANMORE, Anthony Thomas
STEPHENS, Keith Stanley Archer
STOKES, Keith Harry
TAYLOR, Clive
TAYLOR, Robert Stewart
THIRLWAY, Robin Henry[3]
THORP, Terence Norman[2]
TIDD, Michael Joseph
TOLLIT, Jonathan Niall
TRAVERS, Lawrence Brendan
TURNER, Anthony Edward[2]
UNDERWOOD, David Ronald[2]
VAUGHAN, Bryan Martell
VINCENT, David Charles
WALLER, Alan
WARD, Cedric Robert
WASON, Laurence James
WATSON, James Patrick
WAYLETT, Dennis Arthur
WHITEHEAD, Rex Douglas[1]
WILKINSON, James John
WILSON, David[2]
WYBORN, John Howard
YHAP, Oswald Kenneth[2]

The following candidate has satisfied the examiners in the subjects Mathematics; Applied Mechanics; Heat, Light and Sound; and Principles of Electricity of Part I:

SIMS, Roy Blackmore[3]

[1] *Also satisfied the examiners in the subject of English* [2] *Also satisfied the examiners in the subjects Strength of Materials and Theory of Structures*
[3] *Also satisfied the examiners in the subject of Theory of Structures*

The following candidates have satisfied the examiners in the subject of English:

ALISON, David Cowdray
BANKS, John Gray
BRETT, John
CARR, Donald Peter
CONNOLLY, Harold
COYLE, John
DALRYMPLE, Gordon David
DAVIES, Gwynfryn John
DUCK, Ivan Alfred
FERRAO, Romeo Agostinho
HALL, John
HARROWER, Robert
HILD, John Henry
HOLMES, Sydney Albert
HUNTER, Edward Ivison
JACOBS, Simeon Paul
KEMERY, John Reginald
KHAN, Mohammad Rafique
LAST, John Brian
LAZELL, John Victor
LEAVER, Bernard
LOVETT, Francis Joseph
McINTYRE, Alan Munro
McKENZIE, Allan Robert
MANSON, Robert Patrick
MILES, Dodwell Rees
MORRIS, Derek Malcolm
MUKHERJEE, Subimal
NELMES, Graham Ronald
ORR, Alan Farquhar
PRICKETT, Roy Thomas
ROBERTS, Ronald Arthur
SILLETT, Peter Norman
SMITH, James Frederick
SPURRELL, Gordon Ernest
TAYLOR, George Walters
THOMASON, Allan
THOMPSON, Neil Arthur
TOOR, Khalil-ur-Rahman
VEACOCK, Gordon
VENN, Albert William John
WESTCOMB, Brian Alfred

The following candidates have been permitted to enter the Examination under special conditions and have satisfied the examiners in the subjects indicated:

ANDERSON, James William[5]
AUDRITT, Leonard George[3 4]
BALDING, George Keith[2]
BENSON, Walter Geoffrey[5]
BHANJA, Roma Prasanna[5]
BINA, John[5]
BLAKESLEY, Michael Anthony[2 5]
BLUNDELL, John James[1]
BOWEN, James Harry[5]
BRUFFELL, William Kenneth[4]
BURNETT, Eric Anthony[3]
CARPENTER, George[1]
CARPENTER, James Grant[3]
CLUTTON, Eric William[1]
COLEMAN, Brian Arthur[4]
COOK, John Bertram Lewis[5]

[1] *Mathematics* [2] *Applied Mechanics* [3] *Heat, Light and Sound* [4] *Principles of Electricity* [5] *Engineering Drawing*

CORDER, Alan[3 4]
DANIELS, Brian Victor[4]
DE BOO, Victor James[4]
DEUCE, Thomas Leslie Grant[3]
DRAPER, Ian Clement[4]
D'SA, Edmund James[1]
DUGGAN, Robin Hugh[5]
ELLERSHAW, James Clifford[1]
ELLIS, Brian Charles[1]
ENDERSBEE, Donald Eric[1]
FORTEY, Joseph William[1 3 4 5]
GALLACHER, Thomas[4]
GIBSON, Stanley[3]
GILES, Rodney Terence Frank[3 4 5]
GRAY, Philip Kirkby[1]
GREEN, Alan Raymond Wheeler[3]
GRIMSHAW, Peter Roy[4]
GROSE, Francis[5]
HAIGH, James Stewart[2 3 4 5]
HAIRE, Thomas Peter[5]
HALL, Peter Alexander[4]
HAQ, Masrur-Ul[2 3 4 5]
HAYTER, Robert John[4]
HEATH, David Alan[1]
HILTON, Brian Thomas[3 4]
HOLLIS, Richard Maxwell[1]
HOLVEY, David John[3 4]
HUGHES, Joe Kenneth Lockley[1]
HULME, John Francis[5]
ISMAIL, Ariff[3 4 5]
KEARNS, Lawrence[3 4 5]
LADBROOKE, John Lawrence[1]
LAWRANCE, David Edward[1]
LAWRIE, William Love[2 4 5]
LEAVER, Bernard[3 4]
LEE, Arthur Thomas Gordon[4]
LILLINGTON, Donald Robert[3]
MAPPLEBECK, John[1]
MARTIN, Anthony David[5]
MAYHALL, John Gerald[5]
MOSS, Brian James[1]
MURDOCH, Ian Robert[4]
MURRAY, Ronald Arthur[1]
NAHA, Asit Kumar[1 5]
NEAVE, Harry[4]
NIRMALALINGAM, Thiagalingam[4]
OGUNRINDE, Gabriel Adegboyega[4 5]
ORTON, Brian[4]
PATON, John [3]
PAYLOR, David Marsden[4]
PEARN, Ian Richard[1]
PIKE, Jeffrey[3 4]
PLACE, Frank[5]
POTTER, Brian Edmund John[4]
POWELL, Ronald Morgan[4]
PRADHAN, Ashok Vinayak[5]
PRINGLE, Keith[2]
PROUD, Robert Gilmour[4]
PYE, Charles Henry[1]
ROBERTS, Ronald Arthur[4]
ROWE, Arthur Ernest[1]
ROY, Deba Brata[5]
RUSSELL, Denis[4]
SAMBELLS, Derrick Frederick[4]
SAXELBY, Alec Martin[1 3 4 5]
SHILLABEER, Robin Noel[5]
SHORT, David John[4]
SILLETT, Peter Norman[4]
SMART, David Charles[4]
SMITH, Jack Anthony[1]
SMITH, John[5]
SMITH, Michael Richard[3]
SMITH, Michael Simes[4]
SPENCE, Malcolm William[3]
STEVENS, Brian Arthur[1]
TAYLOR, George Walters[4]
TRUMPER, Keith Norman[1]
TUBBS, Stanley William[5]
WALKER, George Henry[3]
WEBB, George Samuel[1]
WILLIS, Derek Richard[1]

[1] *Mathematics* [2] *Applied Mechanics* [3] *Heat, Light and Sound* [4] *Principles of Electricity* [5] *Engineering Drawing*

OVERSEA

The following have satisfied the examiners in the compulsory subjects of Part I (Mathematics; Applied Mechanics; Heat, Light and Sound; Principles of Electricity; and Engineering Drawing):

ABAYAGUNAWARDHANA, Kariyawansa Ranaweerakankanamalage Don
ABBAS, Mazhar
ABEYESUNDERE, Neville Mark Christopher
ADJEI, Charles Alexander[2]
ANANDALINGAM, Ramiah[2]
AWUAH, Patrick Gyimah
BALASUBRAMANIAN, S.
BERRY, Trevor Gordon
BHOGAL, Salig Ram
CARTER, Derek Henry
CHAN, Nai Chung
CHAN ENG SOON, Patrick[2]
DOMINIC, David Pedrupillai
DUTT, Sasadhar
EGUAKUN, William[2]
FENG, Hwa Tsun
FERNANDO, Joseph Emmanuel Ephrem
FREEMAN, Joseph Brian Alexander
GLAUCH, George
GUNAWARDENA, Walter Abeysinghe
GUPTA, Harish Chander
HAQ, M. Anwarul[2]
HO, Pun Hing
HO, Wing Siu
HSIA, Veelin
JAGANNATH, Srinivas[1]
JAYASUNDARA, Stanley Upatissa Samaradiwakara[2]
KANDIAH, Vijeyaratnam
KARUNARATNE, Edward Walter
KARUNARATNE, Vidanage Mahinda
KARUNATILLEKE, Hemasiri Dias Silva
KHAIRULBASHAR, Sayed Mohammed
KODITUWAKKU, Kalahe Kaluaracchige Jayatunga
KOH THIAM HOCK[3]
KOMEH, Joseph Asenkye
KWOK, Kwong Yuen
KWOK, Yum Kuen
LALWANI, Gul Kalachand
LAM, Hon Kay
LEE, Chung Kai
LEUNG, Lee Shing
LIM CHEE MENG[2]
LUK, See King
LUK, Woon Kwan
LUOPA, John August
MAK TING-HEI, Augustine
MENDIS, Liyana Belson[1]
METTANANDA, Asoka
MUNASINGHE, Nissanka Tissa Kumara[2]
NANUA, Amarjit Singh
NARENDRAN, Namasivayam
ODOI, Kwaku[2]
QUAIDOO, Emmanuel Adolphus
RAMALINGAM, Vythilingam
RICHARD, Arulnesparen
ROCQUE, Michael
SATCUNANATHAN, Supramaniam
SAW HOW TEIK[3]
SCHOLES, Ian Stuart
SEKARAJASEKARAN, S/O Arasaratnam
SENARATNE, Mulleriyawage Calyanakirthi Kulatillake[2]
SETHI, Harbanash Lal
SRINIVASAN, T. R.[1]
SUNTHERALINGAM, Vallipuram
THIAGARAJAH, Vijayanathan
TONG, Kin Wah
URI, Liquornik[1]
VAITHEESPARA, Tharumalingam[2]
VIVEKANANTHARAJAH, Singharasa
WEERAKOON, Laksham Upali[2]
WILSON, James Kobina
WU, Augustine Bick Lun
WU, Sui Lun Paul
YOUNG, Put Hing

[1] *Also satisfied the examiners in the subject of English* [2] *Also satisfied the examiners in the subjects Strength of Materials and Theory of Structures*
[3] *Also satisfied the examiners in the subject of Theory of Structures*

The following candidates have satisfied the examiners in the subject of English:

AHMED, Syed Misbahuddin
BIRNINGHAM, Peter James
BRIGHTON, Leonard Ernest
BUCKINGHAM, Douglas Ramage
CHAN, Wing Cheong
CHANDRA, Vikash
COUSINS, Raymond Walter
DRUMMOND, John Greig
FERNANDEZ, Michael
FERNANDO, Warnaculasuriya Gregory Alfred
FOSTER, Elson Peter
FOSTER, Ronald
FRIEDBERG, Andrzej
GANGULY, Sunil Baran
HILLEL, Jamil
HUSSAIN, Mohammad Mosharraf
JEHANGIR, Mohammad
LEWIS, Terence Edward Frith
LYONS, John James
MORRISON, James Petts
NAYER, Krishnan P.
O'NEILL, Peter Maurice
RAMACHANDRAN, S. G.
RIXEN, Frank
SAPRE, Laxman Purshottam
SMITH, Geoffrey Stanley
SMITH, William James
SPENCER, Samuel Thuraisingam
SUNDARESA RAO, Katharikuppam
TILLMAN, Philip Robert Alec
WHITE, George Charles
WIJENATHAN, Doraisamy
WRIGHT, Reginald John

The following candidates have been permitted to enter the Examination under special conditions and have satisfied the examiners in the subjects indicated:

ARIYANAYAGAM, George Ariyarajah[2 3 4 5]
BARCLAY, Henry Ulric[5]
BHATT, Chandravadan Jaishanker[5]
BLACKLOCK, Robert[5]
CONNELLY, Alexander[4]
COUSINS, Raymond Walter[4]
DAS, Nihar Ranjan[2 5]
DE ZOYSA, Lalithe Nihal[5]
DONOVAN, Peter Joseph[4]
FOWELL, Michael John Haralambos[4]
GILBERTSON, George Alfred[4]
HAMEED, Muhammad Abdul[5]
HENSHAW, Alan David[3 4]
JESURATNAM, Philips Thiruchelvam[3 4 5]
JUKAR, Kishor Keshavrao[5]
LAIRD, Gordon Alexander Glenworth[4]
MCKELVIE, Ian James[5]
MCKENNA, Desmond Ernest[4]
MAHADEVAN, Ramamirtham[5]
MALHOTRA, Dev. Raj[5]
MOYE, Sharad Gopal[5]
MUKHERJI, Rabindranath[2 5]
NATH, Bhupendar[5]
NEWTON, Peter Barton Eric[3]
OJEKWE, Sammy Lawson Olisaeloka[2 3]
O'NEILL, Peter Maurice[4]
PAIS, Aloysius[2 4]
PHILLIPS, James Frederick[1]
RAGUNATHAN, Ambalavaner[5]
RATCLIFFE, Walter Stebbing[4]
SANMUGARAJAH, Ambalavarnar[5]
SELVARAJAH, Kandiah[5]
SMITH, Geoffrey Stanley[2]
STUART, Allan Ernest Garth[3 4 5]
SUKUMARAN, Gopalan Nair[5]
SWAMINATHAN, Rajagopala[5]
TAYLOR, Edgar John[2 3 4 5]
THANGARAJ, S. I. Jesudasan[5]
THIRUNAVUKKARAS, Kandiah[5]
TILLMAN, Philip Robert Alec[3 4]
TOWNSEND, Phillip Edward[3]
WICKHAM, Stanley George[4]
WILLIAM, Herbert Alfred[1]
WILLIAMSON, John Raymond[4]

[1] *Mathematics* [2] *Applied Mechanics* [3] *Heat, Light and Sound* [4] *Principles of Electricity* [5] *Engineering Drawing*

THE INSTITUTION EXAMINATION

List of Successful Candidates (*contd.*)

THE INSTITUTION EXAMINATION (PART II) APRIL 1958

BRITISH ISLES

ADDISON, Geoffrey[3 4]
AYRE, John Kenneth[1]
BALISTER, Michael[1]
BARKHAM, Ronald Nichol[3 4]
BARNETT, Christopher Frank[2]
BARVE, Sharad Purushottam
CAMPBELL, John Malcolm[1]
CAVANAGH, Eric Joseph[1]
CHAPMAN, Robert Lancelot[3 4]
CHAUDHRY, Sushil Prakash
DARBYSHIRE, Leslie[1]
DAWSON, Michael John Groombridge[3]
DYMOTT, Peter Harry[1]
FLETCHER, Charles Frederick[3 4]
GARD, Alan Edward Norman[1]
HIRD, Colin[3 4]
HO LYE-HON[2]
HUNTLEY, Michael William Elliott[3 4]
JAMES, Antony[1]
JENKINS, Gerald Walter[1]
JOLLEY, William Peter[1]
KHOKHAR, Abdur Rashid
KOTANDENIYA, Lionel Basil[1]
LOCKTON, Michael Harry[1]
McDONALD, Kenneth[3 4]
MILLWARD, John David[1]
MORRIS, George Edwin[1]
RAMSAY, Walter Ronald[3 4]
ROBSON, Brian[1]
RYLE, John William[3 4]
SIMMONS, John Robert Kenneth[1]
SMITH, Thomas Alexander[3 4]
TEO CHYE POH
THOMAS, Alun David[3]
TILLEY, Brian John[2]
TIMMIS, Albert Gerald[1]
VIJAYENDRAN, Chinnathamby
WILMAN, Hugh

OVERSEA

ALLANAH, Vincent Eric Nwokocha[4]
BHATKAR, Chandrakant Pandurang
DAS, Arun Kumar
FIELD, Denis Michael
FRANCIS, Anthony Pillai
HOOGHAN, Naramolak-Singh Ram-Singh
JAYENDRAN, Ariacutty[1]
MEHTA, Ramchandra Nathalal
ROZENSTEIN, Solomon
SAWHNEY, Prem Sagar
SHAH, Rameshkumar Chunilal
SOYSA, Warusahannadige Neil
SUNDARAM, Kanapathippillai Thirugnana
THAPAR, Baldev

[1] *Electrical Engineering I and II* [2] *Engineering Physics* [3] *Thermodynamics* [4] *Mathematics*

THE INSTITUTION EXAMINATION (PART III) JUNE 1958

BRITISH ISLES

ABBOTT, Warwick Reginald
ADDISON, Geoffrey
ALLCORN, Kenneth Walter
ALLEN, Ronald Walter[1]
AUSTIN, Bryan Robert[1]
BAKER, George Edward March[1 3]
BALISTER, Michael
BARKHAM, Ronald Nichol
BATE, Norman William
BENN, Charles Brian
BERRY, Peter John[1]
BETTIS, Kenneth John[1]
BOWEN, Kenneth Edward[1]
BOWLER, Kenyon George Eric
BRADLEY, David[6]
BRYDEN, Eric[1]
BURGOYNE, David Michael[1]
BUTTREY, Michael
CHADNEY, Donovan Colin[1]
CHAPMAN, Robert Lancelot[2 6]
CHEESEMAN, Roy Lawrence[1 3]
CHORLEY, Francis Kenneth[1]
CLOUGHLEY, Robert James
COOK, Graham Arthur[1 3]
CORREIA, John Basil[1 6]
CROWTHER, Peter John[1]
CRYER, Derek Frank[1]
CUNNINGHAM, Donald[6]
CURRY, Robert George
DANDO, Graham[1 3]
DAVEY, Edward Keith
DE COURCY BOWER, John Bingham[1]
DERBYSHIRE, William[1]
DEWHURST, Geoffrey[1 3]
DIXON, John Francis[1]
EDIRISINGHE, Don Francis[1]
FERRETT, Neil Antony[1]
FIELDING, Allan[4 6]
FLETCHER, Charles Frederick[4 6]
FORSTER, Graham Arthur
FORSTER, John[4]
FOX, Daryl Robin Osmund Shaw[1]
FREENEY, John Brendan[1]
GALLACHER, Joseph[1]
GRADWELL, Ian[7]
GRIME, John[1]
HALLAM, Trevor James[6]
HANCOCK, Roger Martin
HARRIS, Denis John[1]
HART, Geoffrey Terence[1 3]
HECKLE, Desmond William[1]
HEWITSON, Leslie Gadsden
HIRD, Colin[1 4]
HOLLAND, Brian Alfred[1]
HUCKLE, Derek[6]
KELLY, Stephen[1]
KHOKHAR, Abdur Rashid[1]
KING, Ian Vernall[1]
KOTANDENIYA, Lionel Basil[1]
LAKE, Malcolm Winfield[4]
LEWIS, Vernon John[1]
LOCKLEY, James Alan
LYON, Derek Charles[1]
McDONALD, Kenneth[4]
MARK, John Richard[1]
MARTIN, Arthur George[1 3]
MEACHER, Edward Charles[1]
MIFSUD BONNICI, Maurice Edward
MITCHELL, Terence[6]
NICHOLLS, Malcolm Robert[1]
NUGENT, Brian[1 2]
PAGEDAR, Arvind Kamalakar[1 6]
PAPWORTH, George Geoffrey Guy[1]
PASMORE, Tom[1]
RAMSAY, Walter Ronald[4]
REYNOLDS, Anthony Charles[1]
RINTOUL, John Howard[6]
ROY, Rathindra Nath[1]
RUMFITT, Colin[4]
RYLE, John William[1]
SAMBASIVAM, Thiagarajah
SHAW, Frank Derek
SHORT, Allan[1]
SMITH, Desmond[1]
TEAGUE, Bryan Thomas[1]
THOMAS, Gwyn[1 3]
TURNER, Charles William[1]
UNDERWOOD, Brian William
WAKEFIELD, John Robert[4]
WARR, Neville Leon[1]
WIJESENA, Pitigala Kankanange Jinadasa[1 4]
WILLDEY, Geoffrey Michael[1]

OVERSEA

ARIYANANDA, Kamburugamuwe Lokuruge[3]
ARUMUGAM, Thirumugam Vignarajah
DATA, Sharadchandra Govind[2]
GALANDER, Mohamed Abdalla[1 4]
JAYAWICKRAMA, Priya Padma[3]
KAMALANATHAN, Sivagurunathar[3]
MARATHEY, Jayanta Purandara[1 3]
NAGARKATTI, Durgesh Narayan[2]
PERERA, Kuda Gonaduwage Dharmasena
PERERA, Marcus Vincent Romanis[1 3]
RADHAKRISHNAN, Thangavelu[1 4]
RAJAGOPALARAO, Patnayakuni[8]
RAJA RAO, Yadatore Narayanarao
RAMCHANDRAN, Karumanassery Parasuram[3]
SEEHRA, Kirpal Singh[2 6]

[1] *Advanced Electrical Engineering* [2] *Electrical Machines* [3] *Electrical Measurements* [4] *Electricity Supply*
[5] *Electronic Engineering* [6] *Utilization of Electrical Plant* [7] *Line Communication* [8] *Radio Communication*

District Meetings

ARRANGEMENTS for District Meetings in October other than those in the area of a local Centre.

October 1958

OXFORD (At the Demonstration Room, Southern Electricity Board, 37 George Street, Oxford, at 7 p.m.)

8 *Wednesday* DR. R. L. F. BOYD 'Rockets and Satellites'

READING (At the George Hotel, King Street, at 7.15 p.m.)

13 *Monday* R. WOOD 'Fundamentals of Fuel Efficiency in the Generation of Electricity'

Forthcoming Events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

E EDUCATION DISCUSSION CIRCLE
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
O ORDINARY
R RADIO AND TELECOMMUNICATION SECTION
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and Monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full programme of London meetings is given in the meetings card.

October 1958

O **9** *Thursday* S. E. GOODALL, M.SC.(ENG.), F.Q.M.C. Inaugural Address as President‡

I **13** *Monday* The President will open a discussion on 'The Rationalization of the Avenues of Higher Education for Electrical Engineers'*

M **14** *Tuesday* J. K. WEBB, M.SC.(ENG.), B.SC.TECH. Chairman's Address 'The Scope of the Measurement and Control Section'‡

U **16** *Thursday* R. A. MARRYAT, B.SC.(ENG.) Chairman's Address 'Installation Engineering'‡

E **20** *Monday* G. R. NOAKES will open a discussion on 'The Presentation of Electrical Science in Schools' before the Education Discussion Circle* (At 6 p.m., tea at 5.30 p.m.)

R **22** *Wednesday* G. MILLINGTON, M.A., B.SC. Chairman's Address 'Random Thoughts of a Propagation Engineer'‡

R **27** *Monday* J. SWAFFIELD, PH.D., B.SC.(ENG.), *and* D. L. RICHARDS, B.SC.(ENG.) 'Rating of Speech Links and Performance of Telephone Networks' (Paper No. 2666 R) *Synopsis:* June 1958
D. L. RICHARDS, B.SC.(ENG.), *and* J. SWAFFIELD, PH.D., B.SC.(ENG.) 'Assessment of Speech-Communication Links' (Paper No. 2605 R) *Synopsis:* April 1958

M **28** *Tuesday* D. T. N. WILLIAMSON will open a discussion on 'Electronic Control of Machine Tools'†

S **29** *Wednesday* D. P. SAYERS, B.SC. Chairman's Address 'Art, Craft and Rampart'‡

* No advance information will be available, and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

British Nuclear Energy Conference

NEW MEMBER SOCIETY

AT a meeting of the B.N.E.C. Board on the 16th July 1958 it was decided to admit to membership the Joint Panel on Nuclear Marine Propulsion.

This organization was set up jointly in 1956 by the following four societies: the Institute of Marine Engineers, the Institution of Naval Architects, the Institution of Engineers and Shipbuilders in Scotland, and the North-East Coast Institution of Engineers and Shipbuilders.

The admission of this new body brings the total number of constituent societies comprising the B.N.E.C. to nine.

LECTURE SYMPOSIUM ON THE GENEVA CONFERENCE

To help scientists and engineers to assimilate the large amount of material (over 2000 papers) produced for the second International Conference on the Peaceful Uses of Atomic Energy (Geneva, 1st–13th September 1958), the B.N.E.C. have planned a one-day Lecture Symposium to take place in March 1959.

For the purposes of the symposium, the Geneva Conference papers will be classified into six or seven groups, and leading experts in each field will attempt to bring out the most important aspects of the new information. The lectures will be printed in the April 1959 issue of the *Journal of the B.N.E.C.*

Further details will be announced as they become available.

SYMPOSIUM ON NUCLEAR FUEL CYCLES

The Institute of Physics are arranging a Symposium on Nuclear Fuel Cycles, to take place in London on the 22nd and 23rd January 1959. The programme will include three sessions under the following headings:

Session 1 (*a*) Long-term reactivity changes
(*b*) Theory of once-through fuel cycles
(*c*) Perturbations due to fuel cycles

Session 2 Optimization of fuel cycles for nuclear power stations

Session 3 Fuel-cycle operational problems

The symposium is intended mainly for persons working in the field and will deal with the applied-physics aspects of the fuel cycles forming the basis of the immediate nuclear-power programme. Abstracts (but not preprints) of the papers to be presented will be available early in January. The Symposium will be published only in the *Journal of the B.N.E.C.*

Application forms are obtainable from the Institute of Physics, 47 Belgrave Square, London S.W.1. Further details will be announced later.

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH AUGUST 1958

	No. of Contributors	£	*s.*	*d.*
£1000 and over	6	6000	0	0
£100 to <£1000	30	6586	3	0
£5 to <£100	865	9169	1	2
£2 to <£5	2078	5715	19	5
Under £2	24142	12615	6	3
		£40086	9	10

PROGRAMME OF MEETINGS

SESSION 1958–59

THE programme card of London Meetings for the first half of the Session is being sent with this issue to all members not residing within the area of a Local Centre or Sub-Centre.

Any member living in the provinces who often visits London, and is thus able to attend London Meetings, may obtain a copy of the London card on application to the Secretary.

HUNTER MEMORIAL LECTURE

AS already announced, the Council have accepted an offer from British Insulated Callender's Cables Ltd. to provide funds to establish a permanent memorial to the late Philip Vasser Hunter, C.B.E., a Past-President and Honorary Member of The Institution, who was for many years a Director of the Company.

The memorial will take the form of a lecture for electrical engineers to be known as the 'Hunter Memorial Lecture'. At the discretion of the Council, the lecture will be delivered annually either in London or at one of the Local Centres or Branches of The Institution and, if thought fit, be repeated at one or more of the Local Centres or Branches. The first lecture will be delivered in the Institution building on the 8th January 1959 by Dr. L. G. Brazier, B.SC., MEMBER, Director of Research and Education of British Insulated Callender's Cables Ltd., and will be repeated at the Mersey and North Wales Centre and at the North-Eastern Centre on the 2nd and 4th March 1959 respectively.

The Council have welcomed this generous offer because they feel it is a fitting memorial to an Honorary Member who, for a period of over 50 years, devoted much time and energy to the work of The Institution. His professional work showed great initiative and ability in bringing to the service of the community the latest developments in the science and art of electrical engineering. The new lecture will therefore be complementary to the two well-known named lectures: the Kelvin Lecture, which is presented annually by a physicist to engineers to describe new advances in the realm of pure science, and the Faraday Lecture, which is delivered by an engineer to informed laymen about recent electrical-engineering achievements. Between these will come the Hunter Memorial Lecture, by an electrical engineer to electrical engineers on advances in electrical-engineering science.

APPOINTMENTS AND NOMINATIONS

VICTORIA AND TASMANIA OVERSEA COMMITTEE

THE Council have appointed Mr. Pendril Davies as Honorary Secretary of the Victoria and Tasmania Oversea Committee.

B.S.I. SUB-COMMITTEE CEB/6/5—CONCRETE TRANSMISSION POLES

The Council have nominated Mr. N. G. Simpson, MEMBER, to serve as their representative on the above Sub-Committee.

NATIONAL SOCIETY FOR CLEAN AIR—YORKSHIRE DIVISIONAL COUNCIL

The Council have nominated Mr. A. J. Coveney, MEMBER, together with a deputy to be chosen by him, to serve as their representatives on the above Council in place of Mr. E. Lunn, MEMBER.

BRUNEL COLLEGE OF TECHNOLOGY—GOVERNING BODY

The Council have nominated Mr. D. P. Sayers, B.SC., MEMBER, to serve as their representative on the above governing body.

REGIONAL COUNCIL FOR FURTHER EDUCATION FOR THE SOUTH WEST—NORTHERN AREA ENGINEERING ADVISORY SUB-COMMITTEE

The Council have nominated Mr. F. B. Allcock, B.SC.TECH., MEMBER, to serve as their representative on the above Sub-Committee.

REGIONAL COUNCIL FOR FURTHER EDUCATION FOR THE SOUTH WEST—SOUTHERN AREA ENGINEERING ADVISORY SUB-COMMITTEE

The Council have nominated Mr. S. G. Monk, M.SC. (ENG.), B.SC., MEMBER, to serve as their representative on the above Sub-Committee.

CITY OF BIRMINGHAM COLLEGE OF TECHNOLOGY—ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. G. F. Peirson, MEMBER, to serve as their representative on the above Committee.

SOUTHEND MUNICIPAL COLLEGE—ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. H. T. Prior, B.SC.(ENG.), ASSOCIATE MEMBER, to serve as their representative on the above Committee.

HACKNEY TECHNICAL COLLEGE—BOARD OF GOVERNORS

The Council have nominated Dr. F. T. Chapman, C.B.E., B.SC., MEMBER, to serve as their representative on the above Board of Governors.

WANDSWORTH TECHNICAL COLLEGE—BOARD OF GOVERNORS

The Council have nominated Mr. D. W. Hopkin, MEMBER, to serve as their representative on the above Board of Governors.

PADDINGTON TECHNICAL COLLEGE—BOARD OF GOVERNORS

The Council have nominated Mr. D. W. Hopkin, MEMBER, to serve as their representative on the above Board of Governors.

POPLAR TECHNICAL COLLEGE—GOVERNING BODY

The Council have nominated Mr. W. H. L. Lythgoe, MEMBER, to serve as their representative on the above governing body.

MINISTRY OF EDUCATION, NORTHERN IRELAND—ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING

The Council have nominated Mr. J. R. W. Murland, B.SC.(ENG.), MEMBER, to serve as their representative on the above Committee.

BATTERSEA COLLEGE OF TECHNOLOGY—ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING

The Council have nominated Mr. F. J. Lane, O.B.E., M.SC., MEMBER, to serve as their representative on the above Committee.

BRISTOL COLLEGE OF TECHNOLOGY—BOARD OF GOVERNORS

The Council have nominated Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC., VICE-PRESIDENT, to serve as their representative on the above Board of Governors.

BOOTLE MUNICIPAL TECHNICAL COLLEGE—GOVERNING BODY

The Council have nominated Mr. J. Collins, MEMBER, to serve as their representative on the above governing body.

DARLINGTON COLLEGE OF FURTHER EDUCATION—GOVERNING BODY

The Council have nominated Mr. D. B. Hogg, M.B.E., MEMBER, to serve as their representative on the above governing body.

INTERNATIONAL CONVENTION ON MICROWAVE VALVES

THE papers and other contributions and discussions at the recent International Convention on Microwave Valves will be published in the form of three Supplements to Part B of the *Proceedings* (Nos. 10–12), towards the end of November, December and January. Application forms will shortly be sent to all those who requested them on their registration forms for the Convention. Any others requiring copies of the Supplements should apply to the Secretary without delay, enclosing the appropriate remittance. The prices (post free) to members of The Institution are £1 5s. 0d. for each issue and £3 10s. 0d. for the complete set (£2 7s. 6d. and £6 15s. 0d. to non-members).

MEMBERS' GUESTS

MEMBERS are reminded that, under the Bye-laws of The Institution, every member (Students excepted) is entitled to introduce one visitor at each Ordinary Meeting. By direction of the Council, this also applies to all meetings of the Measurement and Control, Radio and Telecommunication, Supply, and Utilization Sections, and to the Informal Meetings.

DISCUSSIONS AT MEETINGS

THE Council desire it to be understood that contributions to the discussions at meetings should not be read from manuscript, since they consider that this form of presentation is contrary to the true spirit of a discussion.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

MEMBERS who are unable to be present at a meeting, or who, if present, do not have an opportunity of speaking, may submit written contributions to the discussion which will be considered for publication in the *Proceedings*. This does not apply to Informal Meetings or Discussion Meetings.

We would also remind members that written contributions on papers published in the *Proceedings* without being read at meetings will be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

STUDENTS' QUARTERLY JOURNAL

PROJECT considerations for Diesel-electric traction are discussed in the first paper in the June 1958 issue of the *Students' Quarterly Journal*. Other papers published deal with the performance and application of magnetic amplifiers, the thermal endurance of insulating materials, the electronic control of resistance welding, metal-enclosed switchgear, turbo-alternator protection, and the Post Office telephone network. Special articles examine the provision of laboratories in technical colleges, and power-plant economics.

Section reports, book reviews, correspondence, and the index to volume 28 are included in this 64-page number.

THE BENEVOLENT FUND

THE Court of Governors acknowledge the receipt of an anonymous donation of £3. There is evidence that this contribution is from a donor who has made similar gifts during the last few months (reported in the *Journal*), and the Court wish to express their warm gratitude for this generous support.

NIELS BOHR GOLD MEDAL

THE Niels Bohr International Gold Medal 1958 has been awarded to Sir John D. Cockcroft, O.M., K.C.B., C.B.E., M.A., D.SC., M.SC.TECH., PH.D., F.R.S., MEMBER. His Majesty the King of Denmark has consented to present the medal personally to Sir John on the 7th October 1958.

SOLID-STATE CIRCUITS

PAPERS representing original contributions in the field of solid-state circuits are invited for presentation at a conference to be held in Philadelphia on the 12th and 13th February 1959, sponsored by the Institute of Radio Engineers Professional Group on Circuit Theory, the Committee on Electronics of the American Institute of Electrical Engineers, and the University of Pennsylvania.

Further information may be obtained from Mr. A. P. Stern, General Electric Company, Electronics Park, Building 3—Room 113, Syracuse, N.Y., U.S.A.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

MEMBERS are asked to note that as from August 1958 the annual subscription rates for publications of the American Institute of Electrical Engineers are as follows:

	£	s.	d.
Electrical Engineering	2	10	0
Transactions	4	0	0
Both the above publications	5	0	0
Communication and Electronics	2	0	0
Application and Industry	2	0	0
Power Apparatus Systems	2	0	0
All three above publications	6	0	0
Bound volume, *Transactions* (three parts)	4	0	0

BRUSSELS CONFERENCE

REPRESENTATIVES of the electrical-engineering societies of 12 countries will be attending a conference to be held in Brussels on the 19th September 1958 under the auspices of the Société Belge des Electriciens. The Institution will be represented by the President, Mr. T. E. Goldup, C.B.E., the Immediate Past-President, Sir W. Gordon Radley, K.C.B., C.B.E., PH.D.(ENG.), and the Secretary.

V.D.E. CONVENTION

THE 50th Convention of the Verband Deutscher Elektrotechniker is to be held in Stuttgart from the 29th September to 4th October 1958. The papers to be read cover a wide range of subjects, including distribution networks, electrical machines, railway electrification, insulating materials, transistor techniques, etc. Further details may be obtained from the Geschäftsstelle der 50 V.D.E.—Hauptversammlung 1958, Stuttgart, Lautenschlagerstrasse 21, Zimmer 403.

EXPRESSING ENGINEERING IDEAS

THE Second Annual Symposium on Engineering Writing and Speech will be held in New York on the 1st and 2nd October 1958. Sponsored by the Institute of Radio Engineers Professional Group on Engineering Writing and Speech, the symposium will concentrate on the engineer's approach to the subject, rather than on that of the professional technical writer.

HARWELL REACTOR SCHOOL

COURSE ON CONTROL AND INSTRUMENTATION OF REACTORS

A COURSE on the control and instrumentation of reactors is to be held at the Harwell Reactor School from the 6th to 11th October 1958. The fee for the course will be 25 guineas, exclusive of accommodation. Application forms and further details may be obtained from the Reactor School, A.E.R.E., Harwell, Berkshire.

ELECTRICAL TECHNIQUES IN MEDICINE AND BIOLOGY

11TH ANNUAL CONFERENCE

BIOLOGY and Computers will be the theme of the 11th annual conference on electrical techniques in medicine and biology at the Nicollet Hotel, Minneapolis, Minnesota, U.S.A., on the 19th to 21st November 1958. The conference is sponsored by the Institute of Radio Engineers, the American Institute of Electrical Engineers, and the Instrument Society of America.

Further details regarding contributions and registration may be obtained from Mr. Robert Erskine, 2753 Fourth Avenue South, Minneapolis.

INTERNATIONAL MEASUREMENTS CONFERENCE

THIS conference, organized by Hungarian, Polish, and Russian scientific societies, will take place in Budapest from the 24th to 30th November 1958. The conference will cover 'technical, economic and organizational questions relating to scientific and industrial measurement, instrument design and manufacture'.

Members wishing to attend should communicate with the Secretary of The Institution as soon as possible.

ILLUMINATING ENGINEERING

SERIES OF SEVEN LECTURES

A SHORT course on illuminating engineering will begin at the College of Further Education, William Street, Slough, in the middle of January 1959. Seven lectures will be given, one evening a week. The course will be conducted by Mr. H. Hewitt, ASSOCIATE MEMBER, covering illuminating engineering, sources, fittings, circuits and auxiliary equipment, home lighting, shop and display lighting, and the architect's approach to lighting and maximum use of daylight.

Inquiries should be addressed to the Lecturer in Electrical Engineering at the College.

SPECIAL COURSES IN HIGHER TECHNOLOGY

A NEW programme of special advanced courses to be given in the London and Home Counties Region during the autumn term 1958–59 has been issued by the Regional Advisory Council for Higher Technological Education. The courses are as a rule part-time (mostly in the evening), but full-time courses which are specially arranged and of not more than three months' duration are included. Full details of the courses are given in the 'Bulletin of Special Courses in Higher Technology, 1958–59, Part 1: Autumn Term', obtainable from the Secretary, London and Home Counties Regional Advisory Council for Higher Technological Education, Tavistock House South, Tavistock Square, London W.C.1, price 3s. post free.

CONGRESO INTERNACIONAL DE AUTOMÁTICA

THIS congress, organized by the Instituto de Electricidad y Automática, will be held in Madrid from the 13th to 18th October 1958. The subjects to be covered include linear and non-linear automation, switching theory, electronic computers, logical design, industrial automation, data processing, and human and economic aspects of automation.

Presiding at the congress will be Mr. J. A. Suanzes, who is the President of the Instituto Nacional de Industria; and a good number of distinguished foreign scientists have accepted invitations to participate and to present papers. Further information may be obtained from Prof. J. G. Santesmases, President of the Organizing Committee, Instituto de Electricidad y Automática, Facultad de Ciencias, Ciudad Universitaria, Madrid.

NEWS FROM THE CENTRES

MERSEY AND NORTH WALES CENTRE

Summer Meeting

THE Annual Summer Meeting, held on the 31st May, took the form of a tour of high scenic interest through coastal and mountainous regions of North Wales, and covered visits to the hydro-electric station at Dolgarrog and to Bodnant Gardens, Talycafn. The outing began at 8.45 a.m., when the party left Birkenhead Woodside station in a special Diesel train, in which they were joined at Chester by the Chairman and Mrs. Makin and other members. The observation-type coach allowed easy viewing of the coast as far as Llandudno Junction, whence the journey was continued by motor coaches up the valley of the Conway to Dolgarrog. The hydro-electric station was built originally by the Aluminium Corporation in 1909 and later taken over and enlarged by the North Wales and South Cheshire Joint Electricity Authority. After an inspection of the machines and control equipment, a buffet lunch was provided through the kind hospitality of the Central Electricity Generating Board.

The afternoon was spent at leisure with a genial sun favouring the proceedings in the 60 acres of National Trust property at Bodnant Gardens. The terrace gardens in front of the house (the residence of Lord and Lady Aberconway) and the less formal portions situated above the River Conway looking across the valley to the Snowdon range contain much of interest and beauty.

Leaving Bodnant, the route followed the west side of the river to Conway and then along the coast, with views of Anglesey and the Menai Straits, to Bangor. Here a very welcome tea was taken at the M.A.N.W.E.B. centre, and we record our thanks to the Board and to Mr. R. N. Pegg, Sub-Area Manager, and our appreciation of the cheerful attention by the staff. No doubt they realized they had been excellent hosts when a little later the showroom was filled to capacity, with, in all, some 80 consumers admiring the details of a fine display.

The route to Bettws-y-Coed through the Nant Ffrancon Pass and skirting Llyn Ogwen typifies the austere aspect of the country, only to be followed by the lush greenery which surrounds Bettws-y-Coed—where dinner was waiting.

Golf Tournament

Ideal conditions favoured the full-day Annual Golf Tournament at the Southport and Ainsdale Golf Club on the 17th June, and as always this championship course was in magnificent condition for the enjoyment of the 60 competitors. Discounting most of the personal opinions, scores in general ran remarkably true to handicap, as in only the Open Singles for handicap 13 and under did a competitor—Mr. G. Baker—gain a clear-cut victory, winning by one point from a triple tie for second place.

The G. P. Dennis Challenge Cup and replica for Institution members resulted in an exciting win for Mr. R. S. Ekbery, playing off 12. He and Mr. F. G. Briant, off 8, were level at the end of 18 holes, but he took the honours with the better score for the last nine holes and is to be congratulated on this, his third success in the competition.

Mr. Briant also has held the cup on two previous occasions, and in view of the fact that the first time was 28 years ago, followed by an interval of 25 years, his was a great performance and deserving of better luck.

The prizes were presented by Mr. T. Makin. The event was admirably organized and supervised by Mr. F. J. Brown,

[By courtesy of the C.E.G.B.

A group at Dolgarrog during the Summer Meeting of the Mersey and North Wales Centre on the 31st May

to whom we tender the thanks of the Centre. Finally, the Institution Benevolent Fund profited to the extent of over £80.

E. W. A.

[By courtesy of the C.E.G.B.

Buffet lunch at Dolgarrog

The group in the centre includes (*left to right*) Mr. K. N. Swash, Mr. R. N. Pegg and Mr. T. A. Maguire

NORTH STAFFORDSHIRE SUB-CENTRE

Hearing and Seeing

A JOINT meeting with the local Centre of the Institution of Post Office Electrical Engineers was held at Stone on the 14th April. Mr. R. W. Palmer officiated, in the absence of both the Sub-Centre Chairman, Mr. H. A. P. Caddell, and the Centre Chairman of the Institution of Post Office Electrical Engineers, Mr. H. R. Harbottle. As he happens to be the local Vice-Chairman of both Institutions, it is hardly surprising that in Mr. Palmer's opening remarks it was not always quite clear on whose behalf he was congratulating himself on the close co-operation which exists between the two Centres.

The lecture given by Dr. E. C. Cherry, entitled *The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering*, was most stimulating and thought-provoking. He explained that, while engineers could measure certain parameters of speech and sight, the system based on these was not necessarily satisfactory to the user. The user had not yet been included as an integral part of the system, as no-one was yet completely aware of how he saw or heard. Dr. Cherry therefore described experiments he was conducting to determine the mechanism of seeing and hearing, and quoted many of the intriguing results he had obtained.

Mr. H. Baker opened the discussion, which was joined by many other members and enabled Dr. Cherry in reply to illustrate even more clearly the need for research in this field. In the vote of thanks Mr. R. W. Conway remarked what a wonderful device was the human mind and, by comparison, what a poor imitation was the product of the engineer.

Annual General Meeting

The tenth Annual General Meeting was held at Stafford on the 5th May. The Chairman was able to report a healthy increase in membership and that, though the average attendance at meetings was rather lower than last year, it was still being well maintained. A successful District Meeting had been held at Burton-on-Trent, and arrangements were in hand for one at Lichfield next session. He referred to the revision of boundaries, under which Burton-on-Trent would be transferred to the East Midland Centre and Crewe would become part of the North Staffordshire Sub-Centre, arrangements which would be to the greater convenience of the members concerned. The Faraday Lecture, with a capacity attendance of nearly 2000, had been an outstanding success, and the Joint Annual Dance and the Annual Dinner had also been very enjoyable. A donation of £15 15s. had been made to the Benevolent Fund from the Entertainment Account.

Mr. Caddell thanked Mr. R. H. Bannister and Mr. H. McCartney, who were retiring from the Committee, and also Mr. W. E. Darby and Mr. J. L. Hewitt, whose terms of office would expire at the end of the session. He also paid a special tribute to Mr. E. Bolton, retiring Honorary Secretary, whose services had been of the greatest value to the Sub-Centre and The Institution. Mr. Caddell also expressed regret on his own forthcoming departure from the Sub-Centre and thanked Mr. R. W. Palmer and Mr. A. T. Chadwick for deputizing for him on several occasions.

The Chairman reported that there had been no further nominations, and those nominated by the Committee were declared elected. A vote of thanks was accorded to the Honorary Auditors, Mr. M. R. Ward and Mr. J. T. Wordley. Mr. J. L. Hewitt and Mr. Wordley were elected as Auditors for the coming session.

At the Ordinary Meeting which followed, four papers on large wind-tunnel drives were read. These were entitled *The Development of Variable-Speed High-Power Drives for Large Wind Tunnels* and *A Variable-Frequency Power Installation for Large Wind-Tunnel Drives*, by Mr. P. McKearney, Mr. L. S. Drake and Mr. E. G. Mallalieu, *Speed Control of Large Wind Tunnels*, by Mr. L. S. Drake, Mr. J. A. Fox, and Mr. G. H. A. Gunnell, and *Automatic Setting of the Flexible Walls of a Large Wind Tunnel*, by Mr. T. Barnes and Mr. C. R. Dunham.

For convenience, Mr. Fox read a combined résumé of the four papers which was amply illustrated by slides and a film of the Bedford installation. The discussion, opened by Mr. A. Asbury and joined by 10 other members, ranged widely over all aspects of this unique installation designed mainly for fundamental research.

In proposing a vote of thanks to the authors, six of whom had been able to attend, Mr. G. H. Gillam said the papers had presented a fascinating subject and had been very much enjoyed. He referred to the large number of people involved and to the team-work which had gone into the production of this equipment, and also to the many branches of engineering and science which had co-operated in its design and construction..

L. G.

SOUTHERN CENTRE

Summer Visit to Mitcham

ABOUT 70 members and their ladies assembled for lunch on the 20th June at the main office block of Mullard Ltd., Mitcham, Surrey. The coach party from the Brighton area had stopped for coffee at the South Eastern Electricity Board's Centre at Horsham on the way north, the Southampton and Portsmouth party having made separate arrangements at Hindhead.

The President, Mr. T. E. Goldup—a Director of Mullard Ltd.—was present at the lunch and welcomed the party. The Southern Centre Chairman, Dr. L. G. A. Sims, suitably responded.

Coaches conveyed the party to the television-tube works, where 14–21 in. tubes were seen in every stage of assembly. Some time was spent with research groups, technical explanations being given by enthusiastic members of Mullard's staff.

The party at lunch

Following tea, a number of Graduates and Students undergoing training at the works mingled with the visitors, and there were many interesting conversations in which the comparison between heavy and light electrical engineering figured predominantly.

Before leaving at 6.30 p.m. each lady member of the party was presented with a memento of the occasion, which, together with the excellent hospitality experienced, was greatly appreciated by all. E. A. L.

Southern Centre visit to Mitcham, 20th June 1958
Left to right: Dr. J. D. Stephenson, of Mullard Ltd., Dr. L. G. A. Sims, Chairman of the Southern Centre, and the President, Mr. T. E. Goldup

THE Editor regrets that the picture at the foot of p. 456 of the August *Journal* was wrongly captioned. The caption should have been '*Mr. and Mrs. S. E. Goodall greeting Mr. and Mrs. B. W. Ricks*'.

NEWS FROM ABROAD

SINGAPORE/MALAYAN JOINT OVERSEA GROUP

Presidential Visit

THE 1957–58 session was for the Singapore/Malayan Joint Oversea Group a most successful one, concluding with an outstanding event in the visit to Singapore and Malaya of the Presidents and Secretaries of the three British engineering institutions in March 1958.

Singapore was the first place during the world tour where the three Presidential parties met and the representatives of the three Institutions were together. Among the number of visits arranged for them were some to places of educational interest, including the University of Malaya, the Singapore Polytechnic Institute, and the Technical College in Kuala Lumpur.

The Joint Oversea Group arranged a banquet for members and their guests in honour of this visit to the Federation of Malaya, and the occasion was graced by the presence of the Prime Minister, Tunku Abdul Rahman, and of other Ministers and dignitaries. The Presidents had the opportunity of meeting the Ministers for Education in Kuala Lumpur and in Singapore, when frank discussions took place on developments in technical education. In Singapore, H.E. Sir William Goode received the Presidents at Government House prior to their departure for Australia. The Presidents' visit to Singapore culminated in a cocktail party held at the Adelphi Hotel on the 15th March, which was attended by Singapore members to wish the Presidents and Secretaries good luck and a happy journey. The evening concluded with entertainment at a Chinese restaurant.

The occasion of the visit will be regarded as unique in the annals of the Joint Oversea Group, to be long remembered by local members as an affair of singular importance.

The Secretary and Mrs. Brasher took the opportunity of visiting a v.h.f. repeater station located at the top of Gunong Pulai, which is in the heart of the jungle country of Johore and approximately 50 miles from Singapore. P. L.

AUSTRALIAN ATOMIC ENERGY SYMPOSIUM

A SYMPOSIUM on the peaceful uses of atomic energy, with special reference to research and applications in Australia, was held in Sydney from the 2nd to 6th June 1958. It was sponsored by universities, industrial undertakings, State and Commonwealth Government departments, and the Australian Atomic Energy Commission.

Papers were classified by sections, the five sections being: (1) materials; (2) power engineering; (3) power auxiliaries and research reactors; (4) basic sciences; and (5) associated techniques.

In addition to the presentation and discussion of papers, a number of excursions were arranged both for Australian and for the many oversea visitors attending. A particular visit of great interest was to the Hifar research reactor at the new A.A.E.C. Research Establishment at Lucas Heights.

Reprints of the papers, together with the discussions, will be ready by about the end of October, under the title 'Australian Atomic Energy Symposium, 1958'. They will be available from the Melbourne University Press, for whom the Cambridge University Press are the U.K. and U.S. agents. The price per set will be about £5.

As such a wide range of subjects was studied, it is not possible to provide full coverage here, but summaries of some papers of particular interest to electrical engineers are given below. The index adjacent to the title indicates the section in which the paper was read.

Atomic Power in Australia—Some Economic Considerations[2]

COMMONWEALTH BANK DISCUSSION GROUP

The paper is concerned with the prospects of using atomic processes for electricity generation in Australia. The Australian power-generation industry is reviewed, and the economic implications of a change-over from coal- to uranium-fired power stations are discussed.

The Economics of Electricity Generation in Queensland and the Potential Employment of Nuclear Reactors[2]

STATE ELECTRICITY COMMISSION OF QUEENSLAND

An endeavour is made to fix a tentative date at which atomic energy is likely to compete with conventional forms of power generation, and to indicate sizes of plant required and cost figures prevailing at that time.

The Hinkley Point Reactors[2]

H. S. ARMS, H. C. BOTTRELL *and* P. H. W. WOLFE

The paper gives an outline description of the station and discusses its output and performance. Design details and operation are discussed, including control, instrumentation and safety precautions.

Nuclear Power Reactor and Turbo-Alternator Interaction under Dynamic Conditions[3]

H. K. MESSERLE *and* J. F. ARMSTRONG

The effect of steam-raising plant on the dynamic stability of turbo-alternators with standard speed governors is investigated, and it is shown that the stability can be modified quite considerably if nuclear reactors are used as heat sources.

The Control and Instrumentation of the Reactor Hifar[3]

G. PAGE

The principles of the safety control systems are outlined, and the electrical safety and interlock circuits are discussed. A brief survey is made of other associated instrumentation, e.g. health monitors and general industrial instruments.

Some Temperature Effects of Geiger–Müller Tubes[5]

R. E. BELIN

The paper describes experiments carried out on organic-quenched tubes with oxide-coated cathodes.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th July to 14th August 1958 the following members called at the Institution building and signed the Attendance Register of Oversea Members:

BROADBENT, D. H. (Geneva)
CROUCHER, D. (Ibadan, Nigeria)
D'AGRELLA, F. J. (British Guiana)
EZRA, S. E. (Calcutta)
FODEN, A. (East London, S. Africa)
GILLMAN, G. A. (Madrid)
HALE, T. C. (Surat, India)
HARMER, L. (Hamilton, Bermuda)
HECTORIDES, P. E. (Nicosia)
HOWELL, W. (Kingston, Jamaica)
KOUYOUMDJIAN, K. (Baghdad)
LYDDIARD, J. A. (Kumasi, Ghana)
MATHEWS, S. C. (Bombay)
PAUL, R. H. (Colombo)
RISTIC, D. (Sydney)
SHEARMAN, B. (Baghdad)
THIRUVARUDCHELVAN, C. (Ceylon)
WOITHE, W. H. (Kano, Nigeria)

The picture shows the President presenting Commemorative Volumes of the Symposium on the Transatlantic Telephone Cable at an informal ceremony at the Bell Telephone Laboratories in New York on the 2nd May, during the recent oversea tour of Mr. Goldup and the Secretary

left to right: Dr. Mervin J. Kelly, Mr. T. E. Goldup, Dr. Austin Wright (who received the Volume on behalf of the Engineering Institute of Canada), Mr. W. K. Brasher, and Mr. Walter J. Barratt (President of the American Institute of Electrical Engineers)

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